Calculation of Possible Mercury MACT Floor Values for Coal-Fired Utilities: Influence of Variability and Approach

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1. SUMMARY

The Environmental Protection Agency (EPA) is currently engaged in development of hazardous pollutant emission limits for coal-fired power plants. For existing sources in categories regulated under Section 112 of the Clean Air Act, the statute directs that these limits be no less stringent than "the average emissions limitation achieved by the best performing 12 percent of the existing sources (for which the Administrator has emissions information)." When limited data are available, the Administrator is to substitute "the average emission limitation achieved by the best performing 5 sources."

More stringent limits can be set, if justified by a cost-benefit analysis.

This report postulates several approaches to how an analysis of this minimal stringency determination, generally referred to as the "Maximum Achievable Control Technology (MACT) floor," might be structured, and then projects the potential impact of pursuing each approach, using available data. The report is organized as follows:

- Chapter 1 presents an overall summary of the report.
- Chapter 2 provides a general introduction to the report, and includes an overview of the legal authority under which these regulatory determinations are made.
- Chapter 3 contains the analytical methodology and reviews the available emission data.
- Chapter 4 presents results from several approaches to applying the general statutory requirements to the emission data.
- Chapter 5 draws conclusions based on the results in Chapter 4, places these results in a broader context of national emissions, and compares this study to other similar studies.
- Several appendices include additional detail.

1.1. Report Scope and Purpose

This report addresses only the regulation of mercury from coal-fired power plants, although EPA may determine that additional hazardous air pollutants (HAPS) from this source category should be regulated. In addition, this report addresses only a portion of the three-step standard-setting process that follows listing a source category for an identified HAP. The first step, identifying appropriate subcategories within the power plant category, is postulated to be based on coal rank, although the report includes a discussion of dividing one coal rank into regional subcategories. The second step, the determination of the MACT floor, is the focus of this report. The third step, cost-benefit analysis of regulatory options more stringent than the MACT floor, is beyond the scope of this report.

The report is further limited in scope with respect to the determination of the MACT floor. As discussed below, determination of the MACT floor includes the analysis of all conditions significantly impacting emissions at the best performing existing units. This report considers only a limited set of such conditions, but the authors believe that even this limited set will provide the reader with an adequate appreciation for how such conditions could ultimately impact determination of the MACT floor. Indeed, it should be emphasized that the purpose of this report is not to project what the MACT floor should be, but rather is to demonstrate the broad range of outcomes that would flow from alternative approaches to making that determination.

1.2. Legal Authority

Section 112 of the Clean Air Act provides EPA the authority to limit mercury emissions from coal-fired power plants, once that source category is listed pursuant to Section 112(c). EPA listed power plants in December 2000. Assuming EPA decides to subcategorize coal-fired power plants by coal rank (bituminous coal, subbituminous coal, and lignite), the number of plants for which emission data exists will make Section 112(d)(3)(B) the operative language for guiding establishment of the minimum stringency of the standard, or MACT floor. This section provides:

> *Emission standards promulgated under this subsection for existing sources in a category or subcategory may be less stringent than standards for new sources in the same category or subcategory but shall not be less stringent, and may be more stringent than . . . . the average emission limitation achieved by the best performing 5 sources (for which the Administrator has or could reasonably obtain emissions information) in the category or subcategory for categories or subcategories with fewer than 30 sources.*

This language has been interpreted in several legal decisions (see Chapter 2) to mean that the "limitation achieved" is not the emission rate measured during tests, but rather the rate of the best performing units "under the most adverse conditions which can reasonably be expected to recur." In a more recent rulemaking and court decision involving determining the MACT floor for new medical waste incinerators, EPA used a technique of identifying the technology represented as "the most effective technology" and then determined the emission rate of similar units under less favorable future conditions. The court concluded, among other things, that "EPA would be justified in setting the floors at a level that is a reasonable estimate of the performance of the 'best controlled similar unit' under the worst reasonably foreseeable circumstances. . . ."

As a result, the challenge to the regulator is two-fold:

- Identify the best performing units, using available emission tests and other data.

- Determine how emissions might vary at those units in the future.

1.3. Report methodology

Consistent with the discussion above, this report considers two major issues:

- How should the best performing units be defined? This report evaluated three approaches, although many more are possible. The first was simply to review the data and select the five units with the lowest emission rate (in pounds of mercury per trillion Btu's) for each coal rank. The second was to identify the five units in each coal rank with the greatest percent reduction in emissions. The third was a hybrid of the first two: the five best units with the lowest emission rate that also achieved at least 20 percent reduction in emissions. For each approach, the third best performing unit was selected as the technology representing the best performing units.

  There are also two fundamentally different ways to estimate mercury emission reductions from existing facilities. In an analysis of the 81 stack tests performed under the EPA's direction in 1999, the Agency used an Emission Modification Factor (EMF) approach. Source owners measured emissions before and after the last piece of control equipment that preceded the emission stack. Reductions from upstream emission controls, if any, were not measured. EPA represented those earlier emission reductions, primarily from particulate control equipment, by using data from units equipped with only the upstream equipment. The result was a combination of actual emission data for a unit with emission reduction estimates inferred from other units, for those units with multiple control systems. All of these data were recorded using the Ontario-Hydro (OH) test protocol. A separate approach to obtaining overall emission reductions is to compare emissions following the last item of control equipment (using the OH protocol), to the mercury content of the coal burned during the test (using a standardized coal analysis protocol). This study used both methods. Combined with the three above approaches to defining "control," this resulted in six scenarios for how "best performing units" might be defined.

In reviewing the available mercury emission data and underlying test reports, a number of data quality issues were identified. As a result, the analysis included an additional step to exclude data from units that failed minimal data quality criteria established by the report authors.

- How might emissions vary at these best performing units in the future? To address this question, the report considers two types of future changes. The first type is under the plant operator's control: using a different coal. While staying within the same coal rank, the operator was assumed to burn a coal that, on average, reflected either the annual average coal used at that plant for the selected parameters, or the coal reflecting the 95th percent "worst" coal for that parameter, considering coal used at all power plants. The 95th percent worst coal was calculated by averaging the parameter in question (such as mercury, chlorine, or sulfur) for all reported coal deliveries (by coal rank) to a plant over 1 year, ordering these plant averages from best to worst in terms of impact on emissions, and selecting the 95th percentile worst average value. Clearly, other definitions of this source of emissions variability are possible. Emission changes based on burning higher mercury coals are easily determined by comparing the worst coals to the actual coal used during short-term stack tests. In addition, the report evaluates the impact of chlorine and sulfur on the performance of control equipment at the best performing units. This report concluded that it is inappropriate to assume the worst coal from a mercury perspective will also be the worst coal from a control technology perspective. As a result, only the greater of these two sources of emission variation was carried forward in the analysis. This differed by coal rank, as discussed below.

  The second type of variability impacting emissions is not within the control of the plant operator. This variability relates to the precision of the test protocols to measure mercury concentration in coal or in flue gases. The OH test protocol has a high relative level of laboratory imprecision, particularly at low mercury concentrations. Imprecision also exists in the measurement of coal mercury, although it is much lower than the imprecision of stack gas mercury concentrations. Emission test error sources other than analytical precision may also be important to emission testing variability, but this report was unable to find an acceptable approach to quantifying such errors.

In addition to these two major issues, during preparation of this analysis the authors noted a substantial difference in the characteristics of northern lignite (primarily from North Dakota and South Dakota), and southern lignite (primarily from Texas and Louisiana). The report considered the regulatory implications of further subcategorizing lignite geographically.

1.4. Results

Table 1–1 presents the results of the analysis. Key results are:

- Different definitions of best performing units will result in different units being in the best five and a different third-best unit representing the best performing units. This, in turn, leads to calculation of different MACT floors.

- For all coals, the impact of coal switching is more dominant than variability in testing. Flue gas testing is a much greater source of uncertainty than coal testing.

- Assuming that a unit might switch to a different source of coal than was typical in 1999, or different than the coal used during its short-term emission test, leads to substantial variability in emissions. For bituminous coals, this manifests primarily in use of a lower chlorine content coal leading to reduced mercury capture by existing pollution control systems. For subbituminous coals and lignites, this manifests primarily in the use of higher mercury content coals leading directly to higher mercury emissions.

- Applying data from plants burning northern lignite to represent the control potential for plants burning southern lignite will likely lead to a more stringent emission limitation for the plants burning the southern lignite. However, it will be difficult to set an independent standard for southern lignite without additional emissions data.

Table 1–1. Summary of the Effects of Measurement Variability

Coal Rank	Scenario No	Plant Name	Unit Number	Technology Control Type	Initial (Test) Hg Emission, lb/TBtu	Calculated Hg Emission (OH Variability), lb/TBtu	Calculated Hg Emission with Variability due to Coal Switching, lb/TBtu	Calculated Hg Emission with Variability due to Coal Switching, including Analytical Variability, lb/TBtu	Calculated Hg Emission with Annual Single Plant Variability due to Coal Switching, lb/TBtu	Calculated Hg Emission wih Annual Single Plant Variability, including Analytical Variability, lb/TBtu
BITUMINOUS	1	SEI - Birchwood Power Facility	1	SDA/FF	0.22	0.58	1.25	2.02	0.28	0.69
	2	SEI - Birchwood Power Facility	1	SDA/FF	0.22	0.58	1.25	2.02	0.28	0.69
	3	SEI - Birchwood Power Facility	1	SDA/FF	0.22	0.58	1.25	2.02	0.28	0.69
	4	Logan Generating Plant	Gen 1	SDA/FF	0.27	0.67	2.56	3.61	0.28	0.68
	5	Mecklenburg Cogeneration Facility	GEN 1	SDA/FF	0.10	0.37	1.27	2.04	0.13	0.42
	6	Logan Generating Plant	Gen 1	SDA/FF	0.27	0.67	2.56	3.61	0.28	0.68
Lignite	1	Lewis & Clark	B1	PS/Wet FGD Scrubber	10.83	12.77	20.31	22.86	8.53	10.29
	2	Coyote	1	SDA/FF	11.72	13.74	24.68	27.45	14.27	16.46
	4	Lewis & Clark	B1	PS/Wet FGD Scrubber	9.16	10.98	17.19	19.57	7.22	8.86
	5	Antelope Valley Station	B1	SDA/FF	2.08	3.04	7.41	9.07	2.17	3.15
	6	Limestone	LIM1	CS-ESP/Wet FGD Scrubber	13.16	15.28	21.53	24.15	15.11	17.36
Lignite North	1	Lewis & Clark	B1	PS/Wet FGD Scrubber	10.83	12.77	11.08	13.05	8.53	10.29
	2	Antelope Valley Station	B1	SDA/FF	5.85	7.34	11.37	13.36	6.11	7.63
	4	Lewis & Clark	B1	PS/Wet FGD Scrubber	9.16	10.98	9.38	11.22	7.22	8.86
	5	Lewis & Clark	B1	PS/Wet FGD Scrubber	9.16	10.98	9.38	11.22	7.22	8.86
SUBBITUMINOUS	1	Craig	C1	HS-ESP/Wet FGD Scrubber	1.58	2.43	10.26	12.17	2.67	3.74
	2	Wyodak	BW 91	CS-ESP/SDA	7.37	9.02	25.45	28.26	11.66	13.67
	3	Wyodak	BW 91	CS-ESP/SDA	7.37	9.02	25.45	28.26	11.66	13.67
	4	Presque Isle	9	HS-ESP	1.26	2.03	4.69	6.05	1.29	2.07
	5	Comanche	2	FF Baghouse	2.66	3.73	4.03	5.30	2.13	3.10
	6	Presque Isle	9	HS-ESP	1.26	2.03	4.69	6.05	1.29	2.07

Scenario 1+4: Best Performing Units as Ranked by Lowest Total Hg Emission (lb/TBtu)
Scenario 2: Best Performing Units as Ranked by Highest Percent Reduction of Mercury Across Control Device(s)
Scenario 3: Best Performing Units as Ranked by Lowest Total Hg Emission (lb/TBtu) and having at least 20% Reduction of Mercury Across Control Device(s)
Scenario 5: Best Performing Units as Ranked by Highest Percent Reduction of Mercury from Coal to Stack
Scenario 6: Best Performing Units as Ranked by Lowest Total Hg Emission (lb/TBtu) and having at least 20% Reduction of Mercury from Coal to Stack

Scenarios 1-3 are based on a combined EMF approach to emission measurement
Scenarios 4-6 are determined from coal mercury content to final emissions
Missing Scenarios result from fewer than 3 plants

1.5. Conclusions

For the limited range of variables considered in this report, it was found that the approach to defining best performing units is highly determinative of the calculated MACT floor. A standard based on units with the lowest emission rates is likely to be several times higher than the actual emission rates measured, because of reasonably predictable changes in emissions from alternative coals being burned at those units in the future. Standards based on greatest percent reduction of mercury are similarly sensitive to changes in coal characteristics that influence control equipment performance, like coal chlorine content.

A much less critical variable is how mercury emissions are measured—whether reductions are based on a measurement combining EMFs (Scenarios 1–3 in this report), or whether reductions are based on comparing coal mercury to emitted mercury (Scenarios 4–6).

2. INTRODUCTION AND LEGAL BACKGROUND

This study evaluates potential regulatory implications of different ways of viewing the available emission data related to mercury emissions from coal-fired power plants. The study is not intended to be exhaustive, or to drive toward a specific recommended emission limitation. Rather, its purpose is to illustrate the large variation in ultimate emission limitations that could result from viewing the relevant emission data and other information from different perspectives.

The study begins by providing an overview of the legal authority and case law related to setting a hazardous emission standard. A general model of how a standard should incorporate variability in emissions from existing sources is then presented. Next, each major area of variability is evaluated for the best performing existing units, and results are presented using different approaches for defining the best performing units. Finally, general conclusions are described in an effort to assist in the regulatory process.

2.1. Statutory Considerations

Section 112 of the Clean Air Act, as amended, provides EPA the authority to regulate HAPs from facilities in the United States. Most source categories are regulated under the provisions of Section 112(d), but special provisions for power plant regulation are included in Section 112(n)(1) of the Act. Given those provisions, EPA may elect to regulate power plant HAPs in a manner that varies from the more traditional approach followed for other source categories under Section 112(d). Nevertheless, this study assumes a traditional regulatory approach, and evaluates possible data interpretations and their implications for setting emission standards under Section 112.

Regulation under Section 112(d) follows a pattern dictated by the statutory provisions, which includes:

1. Listing of a source category for regulation, pursuant to Section 112(c). EPA listed coal-fired and oil-fired steam electric generators in a Federal Register notice on December 20, 2000 (65FR79825, Dec. 20, 2000).

2. Identification of relevant subcategories within the listed category, pursuant to Section 112(d)(1). This step is discretionary. Given that EPA has not yet proposed its regulation, this study assumes that subcategories will be made by coal rank, and considers the implications of further subcategorization of lignite.

3. Determination of the maximum degree of reduction in emissions achievable for new and existing sources in a subcategory, pursuant to Section 112(d)(2). This control level has been dubbed Maximum Achievable Control Technology (MACT).
    a. This step must consider "*the cost of achieving such emission reduction, and any non-air quality health and environmental impacts and energy requirements*".
    b. The maximum achievable reduction for existing sources shall not be less stringent that "*the average emission limitation achieved by the best performing 12 percent of the existing sources (for which the Administrator has emissions information)*," or if there are less than 30 sources in the subcategory, "*the average emission limitation achieved by the best performing 5 sources*". [Section 112(d)(3).] This minimal level of control stringency has been referred to as the MACT floor. For new sources, MACT may not be less stringent than the best performing unit in a subcategory.
    c. EPA is authorized to set a more stringent standard than the MACT floor, if the more general criteria of Section 112(d)(2) are met. These regulatory considerations are generally referenced as "beyond the floor."

The scope of this study is limited in three important ways. First, it examines only emissions from coal-fired power plants. Second, the study considers only the regulation of mercury, although other pollutants classified by the Act as hazardous are emitted from coal-fired power plants. Third, the study focuses on establishment of a MACT floor, and does not evaluate emission reductions beyond the floor.

2.2. Relevant Case Law

Three court cases challenging past regulations are summarized below because they provide direct guidance on how data should be considered in setting a MACT standard. The key issue in these cases relevant to this study is how they direct EPA to consider variability in the best performing units when establishing a MACT floor.

In National Lime Association vs. EPA[1], the court established criteria for the term "achievable" and stated: "to be achievable, we think a uniform standard must be capable of being met under most adverse conditions which can reasonably be expected to recur." Hence, the emission rate taken as "achievable" for the best performing units is not necessarily, or even likely, to be the emission rate recorded when those units are performance tested. Rather, the achievable emission rate would include consideration of future changes that could influence emissions at the units.

In Sierra Club vs. EPA[2], EPA's regulation of medical waste incinerators was challenged. In establishing the emission floor for new units, EPA used a technique of identifying the technology represented as "the most effective technology" and then determined the emission rate of similar units under less favorable future conditions. The court concluded, among other things, that "EPA would be justified in setting the floors at a level that is a reasonable estimate of the performance of the 'best controlled similar unit' under the worst reasonably foreseeable circumstances . . . . " This decision led to the characterization of establishing the MACT floor as determining "the worst of the best."

In Cement Kiln Recycling Coalition vs. EPA[3], the court ruled that variability issues must relate directly to the best performing units, and not merely units of similar design to the best performing units. EPA can consider data related to poorer performing units only to the extent that it directly relates to how emissions could be expected to vary at the best performing units.

2.3. Scope of Study

This study is limited to an examination of mercury emissions from coal-fired power plants. It postulates regulation under Section 112(d) of the Clean Air Act, and does not consider the special provisions applicable to power plants under Section 112(n)(1) of the Act. In addition, it assumes a set of subcategories will be identified within the larger category of coal-fired power plants. Finally, the study does not examine any relevant cost-benefit considerations, or any other considerations related to the beyond the floor analysis discussed above. It focuses on the MACT floor determination.

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1 National Lime Association vs. EPA, US Court of Appeals for the District of Columbia Circuit, 627 F.2d 416, Decided May 19, 1980.
2 Sierra Club and NRDC vs. USEPA, US Court of Appeals for the District of Columbia Circuit, 167 F.3d 658, Decided March 2, 1999.
3 Cement Kiln Recycling Coalition vs. EPA, US Court of Appeals for the District of Columbia Circuit, 255 F.3d 855, Decided July 24, 2001.

3. GENERAL METHODOLOGY

This report focuses on identifying the best performing coal-fired power plants for mercury emissions, and projecting how emissions at these units or at similar units might vary under the worst foreseeable conditions in the future. The steps in this process include:

- Assembling the available relevant information on power plant mercury emissions, most of which is data collected by EPA under two Information Collection Requests (ICRs). ICR-II is the designation for coal quality data for coal delivered to essentially all large U.S. coal-fired power plants in 1999 (every sixth delivery was analyzed for mercury content, chlorine content, heat content, and certain other parameters). ICR-III is the designation for stack-test data for 81 coal-fired power plants.

- Filtering the data to eliminate those irrelevant to the report, or those with characteristics making them highly suspect in accuracy.

- Selecting approaches for defining the best performing units. For example, the units with the lowest emissions, or the units with the greatest percent reduction in emissions.

- Identifying those parameters most critical to projecting how emissions might vary for the best performing units under changing future conditions.

- Evaluating those critical parameters and integrating their effects on projected emissions.

3.1. Relevant Data

Tables 3–1 and 3–2 include a listing of relevant emission data, taken primarily from a report published by EPA.[4] Appendix A presents a detailed review of how these data were reduced to a set deemed both relevant and reliable for further analysis. In general, data were rejected if the emission test included multiple or non-coal fuels, if the combustion process did not use pulverized coal or cyclone firing, or if the recorded data violated one of several quality control tests. Tables 3–1 and 3–2 show the specific data excluded and included, respectively, from analyses in this report.

[4] Control of Mercury Emissions from Coal-fired Eletric Utility Boilers: Interim Report Including Errata Dated 3-21-02, OAQPS/USEPA, EPA-600/R-01-109, April 2002.

Table 3–1. Data Available from EPA Report: Units Excluded from the Analysis

Coal Rank	ID	Plant Name	Unit Number	Coal Type	Facility Type	Control Technology Type	Reason for Exclusion
BITUMINOUS	1	Kline Township Cogen Facility	GEN1	Anthracite Waste	FBC	FF	Waste
	2	Polk Power	1	IGCG			IGCG
	3	Presque Isle	5	Bituminous/Pet Coke	PC Boiler	CS-ESP	Petroleum
	4	Presque Isle	6	Bituminous/Pet Coke	PC Boiler	CS-ESP	Petroleum
	5	Scrubgrass Generating Company L. P.	GEN1	Bituminous Waste	FBC	FF	Waste
	6	Stockton Cogen Company	GEN1	Bituminous/Pet. Coke	FBC	SNCR/FF	FBC
	7	Valley	2	Bituminous/Pet Coke	PC Boiler	FF Baghouse	Petroleum
	8	Wabash River Generating Station	1 + 1A	IGCG			IGCG
Lignite North	1	R.M. Heskett Station	B2	Lignite	FBC	CS-ESP	FBC
	2	TNP-One	U2	Lignite	FBC	CS-FF	FBC
SUBBITUMINOUS	1	AES Hawaii, Inc.	AB	Subbituminous	FBC	SCR/FF	FBC
	2	Clifty Creek	6	Subbituminous/Bituminous	PC Boiler	HS-ESP	Mixed Bitu/Sub
	3	Nelson Dewey	1	Subbituminous/Pet.Coke	Cyclone Boiler	HS-ESP	Petroleum
	4	Shawnee Fossil Plant	3	Bituminous/Subbituminous	PC Boiler	FF Baghouse	Mixed Bitu/Sub
	5	St Clair Power Plant	4	Subbituminous/Bituminous	PC Boiler	CS-ESP	Mixed Bitu/Sub

Table 3–2. Data Available from EPA Report: Units Included in the Analysis

Coal Rank	ID	Plant Name	Unit Number	Coal Type	Facility Type	Technology Control Type
BITUMINOUS	1	AES Cayuga (NY) (formerly NYSEG Milliken)	2	Bituminous	PC Boiler	CS-ESP/Wet FGD Scrubber
	2	Bailly	7 and 8	Bituminous	Cyclone Boiler	CS-ESP/Wet FGD Scrubbers
	3	Big Bend	BB03	Bituminous	PC Boiler	CS-ESP/Wet FGD Scrubber
	4	Brayton Point	1	Bituminous	PC Boiler	CS-ESP
	5	Brayton Point	3	Bituminous	PC Boiler	CS-ESP
	6	Bruce Mansfield	1	Bituminous	PC Boiler	PS/Wet FGD Scrubber
	7	Charles R. Lowman	2	Bituminous	PC Boiler	HS-ESP/Wet FGD Scrubber
	8	Cliffside	1	Bituminous	PC Boiler	HS-ESP
	9	Clover Power Station	2	Bituminous	PC Boiler	FF/Wet FGD Scrubber
	10	Dunkirk	2	Bituminous	PC Boiler	HS-ESP
	11	Dwayne Collier Battle Cogeneration Facility	2B	Bituminous	Stoker	SDA/FF
	12	Gaston	1	Bituminous	PC Boiler	HS-ESP
	13	Gibson Generating Station (03/00 testing)	3	Bituminous	PC Boiler	CS-ESP
	14	Gibson Generating Station (10/99 testing)	3	Bituminous	PC Boiler	CS-ESP
	15	Intermountain	2SGA	Bituminous	PC Boiler	FF/Wet FGD Scrubber
	16	Jack Watson	4	Bituminous	PC Boiler	CS-ESP
	17	Lacygne	1	Bituminous	Cyclone Boiler	PS/Wet FGD Scrubbers
	18	Logan Generating Plant	Gen 1	Bituminous	PC Boiler	SCR/SDA/FF
	19	Mecklenburg Cogeneration Facility	GEN 1	Bituminous	PC Boiler	SDA/FF
	20	Meramec	4	Bituminous	PC Boiler	CS-ESP
	21	Port Washington	4	Bituminous	PC Boiler	DSI/CS-ESP
	22	R. D. Morrow Sr. Generating plant	2	Bituminous	PC Boiler	HS-ESP/Wet FGD Scrubber
	23	SEI - Birchwood Power Facility	1	Bituminous	PC Boiler	SCR/SDA/FF
	24	Salem Harbor	3	Bituminous	PC Boiler	SNCR/CS-ESP
	25	Valmont	5	Bituminous	PC Boiler	FF Baghouse
	26	W. H. Sammis	1	Bituminous	PC Boiler	FF Baghouse
	27	Widows Creek Fossil Plant	6	Bituminous	PC Boiler	CS-ESP
Lignite North	1	Antelope Valley Station	B1	ND Lignite	PC Boiler	SDA/FF
	2	Bay Front Plant Generating	5	Lignite	Cyclone Boiler	Mechanical Collector
	3	Coyote	1	Lignite	Cyclone Boiler	SDA/FF
	4	Leland Olds Station	2	ND Lignite	Cyclone Boiler	CS-ESP
	5	Lewis & Clark	B1	ND Lignite	PC Boiler	PS/Wet FGD Scrubber
	6	Stanton Station	1	Lignite	PC Boiler	CS-ESP
	7	Stanton Station	10	ND Lignite	PC Boiler	SDA/FF
Lignite South	1	Big Brown	1	TX Lignite	PC Boiler	CS-ESP/FF (COHPAC)
	2	Limestone	LIM1	TX Lignite	PC Boiler	CS-ESP/Wet FGD Scrubber
	3	Monticello	1	TX Lignite	PC Boiler	CS-ESP/FF (COHPAC)
	4	Monticello	3	TX Lignite	PC Boiler	CS-ESP/Wet FGD Scrubber
SUBBITUMINOUS	1	Cholla	2	Subbituminous	PC Boiler	PS/Wet FGD Scrubber
	2	Cholla	3	Subbituminous	PC Boiler (Dry Bottom)	HS-ESP
	3	Clay Boswell	2	Subbituminous	PC Boiler	FF Baghouse
	4	Clay Boswell	3	Subbituminous	PC Boiler	PM Scrubber
	5	Clay Boswell	4	Subbituminous	PC Boiler	PS/Wet FGD Scrubber
	6	Colstrip	3	Subbituminous	PC Boiler	PS/Wet FGD Scrubber
	7	Columbia	1	Subbituminous	PC Boiler (Dry Bottom)	HS-ESP
	8	Comanche	2	Subbituminous	PC Boiler	FF Baghouse
	9	Coronado	U1B	Subbituminous	PC Boiler	HS-ESP/Wet FGD Scrubber
	10	Craig	C1	Subbituminous	PC Boiler	HS-ESP/Wet FGD Scrubber

Table 3–2. Data Available from EPA Report: Units Included in the Analysis (continued)

Coal Rank	ID	Plant Name	Unit Number	Coal Type	Facility Type	Technology Control Type
SUBBITUMINOUS	11	Craig	C3	Subbituminous	PC Boiler	SDA/FF
	12	GRDA	2	Subbituminous	PC Boiler	CS-ESP/SDA
	13	George Neal South	4	Subbituminous	PC Boiler	CS-ESP
	14	Jim Bridger	BW 74	Subbituminous	PC Boiler	CS-ESP/Wet FGD Scrubber
	15	Laramie River Station	1	Subbituminous	PC Boiler	CS-ESP/Wet FGD Scrubber
	16	Laramie River Station	3	Subbituminous	PC Boiler	CS-ESP/SDA
	17	Lawrence	4	Subbituminous	PC Boiler	PS/Wet FGD Scrubber
	18	Montrose	1	Subbituminous	PC Boiler	CS-ESP
	19	Navajo	3	Subbituminous	PC Boiler	HS-ESP/Wet FGD Scrubber
	20	Newton	2	Subbituminous	PC Boiler	CS-ESP
	21	Platte	1	Subbituminous	PC Boiler (Wet Bottom)	HS-ESP
	22	Presque Isle	9	Subbituminous	PC Boiler (Wet Bottom)	HS-ESP
	23	Rawhide	101	Subbituminous	PC Boiler	SDA/FF
	24	Sam Seymour	3	Subbituminous	PC Boiler	CS-ESP/Wet FGD Scrubber
	25	San Juan	2	Subbituminous	PC Boiler	HS-ESP/Wet FGD Scrubber
	26	Sherburne County Generating Plant	#3	Subbituminous	PC Boiler	SDA/FF
	27	Wyodak	BW 91	Subbituminous	PC Boiler	CS-ESP/SDA

3.2. *Ranking Approaches*

This report used three basic approaches to show how one might identify which units constitute the best performing units. The first approach used absolute emissions stated in pounds of mercury per trillion Btu's of heat input. Some of these units lacked effective emission control hardware, but benefited from the use of extremely low-mercury-content coal during the performance test (see Table 3–3).[5] This is referred to as Scenario 1.

Recognition of that fact, and that the unit's source of coal could change, led to the second approach: ranking units based on the greatest percent reduction in mercury. This was calculated by comparing the mercury emission rate following the last control device in the control system to the mercury feed rate in the coal being burned. Rankings using this approach are presented in Appendix B. This is referred to as Scenario 2.

The third approach was a hybrid of the first two: ranking units based on the lowest emissions, but only considering units that had at least a 20 percent reduction in emissions, relative to the coal's mercury content. This approach eliminated units that achieved essentially all of their control by virtue of burning an extremely low mercury coal. Results of this hybrid approach are presented in Appendix B. This is referred to as Scenario 3.

Note that in Table 3–3, lignite-fired units are grouped both as a whole, and by geographic region (north and south). As will be shown in Chapter 4, lignite from North Dakota and South Dakota has much lower mercury content than lignite from Texas and Louisiana. These ranking tables offer insight into the substantial impact of disaggregating lignite-fired units into two subcategories.

The method of measuring mercury reduction in Table 3–3 was the EMF method used by EPA in its 2002 mercury report. In general, the ICR-III stack tests were performed across the last control device in the emission control chain. For units with only particulate matter control, this is not important. But for units that also have either sulfur dioxide control and/or nitrogen oxide post-combustion controls, only part of the mercury reduction system was tested. EPA chose to estimate the rest of the control system by using the average mercury reduction at similar units that had only the control system not tested in the multicontrol units. EPA characterized the performance of control systems using an EMF. The EMF was defined as the portion of the original mercury still in the flue gas after passing through the control device. For example, a device that reduced emissions by 25 percent had an EMF of 0.75. One attribute of this metric is that the combined performance of multiple control devices can be calculated as the product of their EMFs. Mercury emissions before and after a control device were measured using the OH test protocol. Scenarios 1, 2, and 3 use this EMF approach to emission rate calculation.

Another approach to identifying the best performing units is to compare the mercury emission rate following the last control device (using the OH test protocol) to the mercury feed rate in the coal. This approach is described in this analysis as the "coal-to-stack" measurement approach, although the second measurement was not necessarily made at the emission stack.

The same approach to identifying best performing units used in Scenarios 1, 2, and 3 was combined with the coal-to-stack approach to emission rate calculations, which are referred to as Scenarios 4, 5, and 6. Appendix B contains tables presenting parametric data for the best performing units under Scenarios 1 through 6.

This report makes no judgment on which of these approaches is the best way to meet the statutory criterion of identifying the best performing units. For example, using low-mercury-content coal can easily be viewed as a "control technique," much as using low sulfur coal is viewed as a control technique

[5] Results for subsequent scenarios have a similar format as Table 3-3. These results are presented in Appendix B.

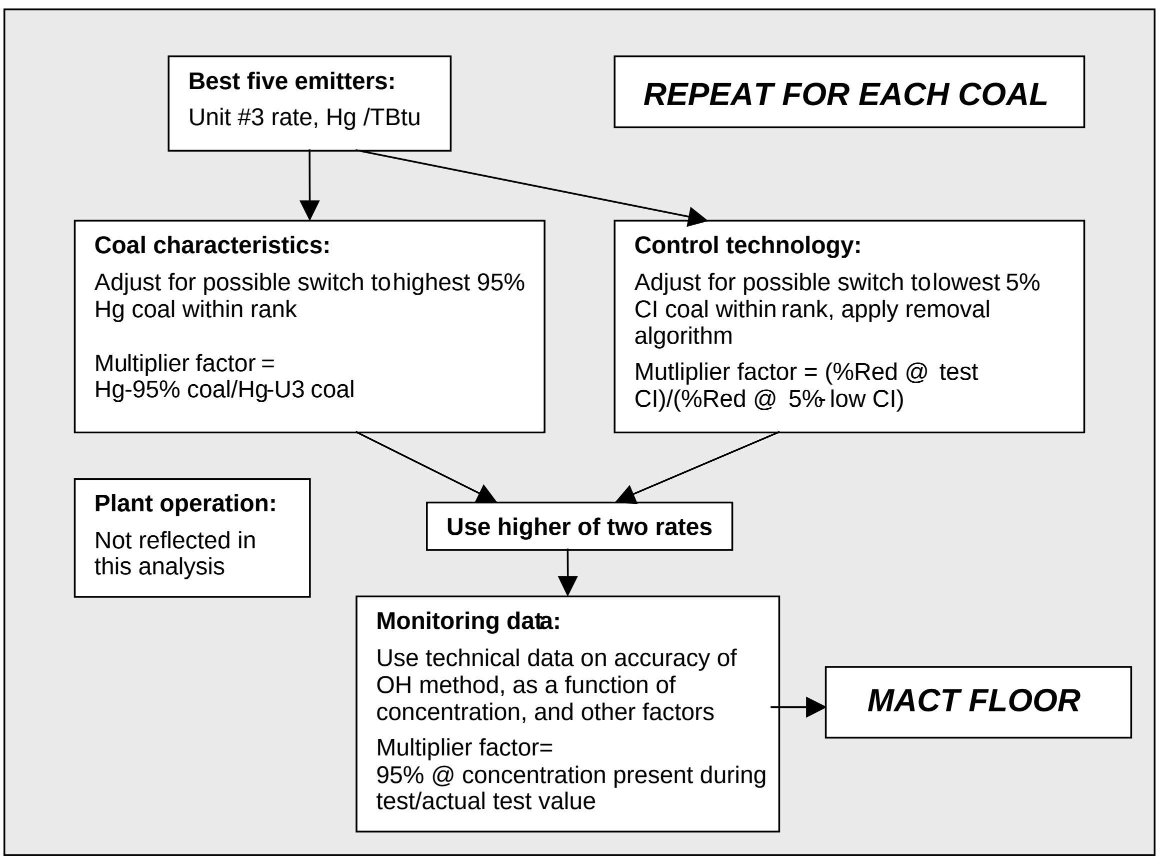
for managing sulfur dioxide emissions under Title 4 of the Clean Air Act. The intent of using different approaches is merely to demonstrate that the MACT floor determining process will produce dramatically different outcomes, with different ways of viewing the issue. In particular, some of these approaches are much more sensitive to future variability possibilities than others.

Once the apparent best performing units were identified using these different approaches, a quality control check was performed on the units. The quality of the data was determined primarily from the test reports that are the basis for the data in EPA's 2002 mercury report. In general, each unit was assigned a rating of one (good) to four (bad), based on evaluation against several parameters. Units rated three or higher were deemed too unreliable for further consideration. Appendix B contains a detailed description of this quality control process and the results. Table 3–4 presents the data associated with best performing facilities that had data of sufficient quality (i.e., data quality flag <3). Finally, Table 3–5 summarizes the third best performing units, upon which a MACT floor may be calculated. Sample calculations for some of the values in Table 3–3 are given in Appendix D.

3.3. Important Variability Parameters

Figure 3–1 presents a conceptual model for incorporating future variability into predicting how units similar to the best performing units might perform under the worst foreseeable conditions. For purposes of this analysis, subcategorization of coal-fired power plants was made by coal rank, with consideration also given to breaking out northern and southern lignites.

Figure 3–1. Structure of Variability Analysis



Once the best performing units were segregated by coal rank, the third-best unit generally was chosen as representative of the best performing units. Selection of a specific unit was necessary to conduct further analysis based on control technology, which generally was not uniform among the five best performing units. For that third-best unit, the impact of switching to a different mercury content coal (within the same rank), and for switching to a different chlorine content coal (also within the same rank) was evaluated using the ICR-II database.[6] Chapter 4 explains how this coal-switching calculation was performed and how algorithms were developed to predict the variation in control technology effectiveness for different coals. Note that for the best performing units, a further review of the ICR-III test report was conducted, and in cases where one of the three best performing units incorporated seriously flawed data, the next best performing unit was used for subsequent variability analysis, as indicated in Appendix B. Appendix B includes a detailed discussion of data quality issues on these best performing units, and explains the reason for eliminating consideration of a unit at this stage in the analysis.

Once the net effect of potential coal switching was estimated, it was necessary to adjust the projected emissions for the best performing units for variability in the original stack-test data. The method used to test emissions of very low concentrations of mercury has a significant level of uncertainty, which should be accounted for in an analysis of how well the best performing units perform. In addition to this analytical sensitivity, emission tests include procedural errors which are often unavoidable given the practical challenges of working with real operating power plants, which have imperfect access to the most appropriate test locations, and immutable design features that may not comport with ideal test protocols. This report discusses those non-analytical emissions testing issues, as presented in Chapter 4, but they are not included in the quantitative analysis of possible MACT floors.

The testing variability was combined with fuel switching variability to project a measure of the “worst foreseeable circumstances” at which these best performing units might operate. The result was an estimate of a MACT floor emission rate, in pounds of mercury per trillion Btu’s, for each of the hypothetical ranking approaches, and for each subcategory of coal-fired power plants.

The report did not conduct an exhaustive assessment of other parameters that might contribute additional variation to future emissions, such as varying plant operation (startup, shutdown, malfunction, load following operation, variation in ambient conditions, or other factors). These factors were either considered secondary to the primary factors that were evaluated, or largely lacking in supporting data on which quantitative estimates could be made. These limitations are discussed more fully in Chapter 4.

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6 Mercury in Coal data from EPA’s Electric Utility Steam Generating Units Section 112 Rulemaking Website, http://www.epa.gov/ttn/atw/combust/utiltox/utoxpg.html#CAAAC

Table 3–3. Parameters for Best Performing Units Ranked by Lowest Hg Emissions (lb/TBtu)

Coal Rank	Plant Name	Unit Number	Technology Control Type	Average Sampled Coal at Plant, lb Hg/TBtu	Average Sampled Coal at Plant, lb Cl/TBtu	Annual Average Coal at Plant, lb Hg/TBtu	Scenario 1: Average Outlet Emission, lb Hg/TBtu	Scenario 4: Average Outlet Emission, lb Hg/TBtu	Scenario 5: Average % Hg Reduction Coal to Stack	Average % Hg Reduction Across Last Control Device	EPA Average EMF for Last Control Device	EPA Average EMF for First Control Device	Scenario 2: Average % Hg Reduction Across All Control Device(s)
BITUMINOUS	Dwayne Collier Battle Cogeneration	2B	SDA/FF	2.16	122,417	5.54	0.10	0.10	95.95	94.25	0.06		94.25
	Valmont	5	FF Baghouse	0.66	3,192	3.09	0.12	0.15	71.16	86.89	0.13		86.89
	Mecklenburg Cogeneration Facility	GEN	SDA/FF	6.94	135,886	6.92	0.17	0.10	98.07	97.91	0.01		97.91
	Logan Generating Plant	Gen	SCR/SDA/FF	13.08	109,006	13.35	0.19	0.27	98.51	98.53	0.02		98.53
	SEI - Birchwood Power Facility	1	SCR/SDA/FF	8.76	73,100	11.28	0.22	0.24	97.45	97.56	0.03		97.56
Lignite	Bay Front Plant Generating	5	Mechanical Collector	4.73	10,028	2.13	3.57	6.99	-51.99	-57.07	1.57		-57.07
	Leland Olds Station	2	CS-ESP	3.81	9,193	6.72	4.02	4.05	25.65	7.29	0.95		7.29
	Antelope Valley Station	B1	SDA/FF	6.03	10,417	6.30	5.85	2.08	42.73	1.11	0.67		1.11
	Stanton Station	10	SDA/FF	7.93	2,690	8.30	7.69	8.14	11.39	-1.02	0.99		-1.02
	Stanton Station	1	CS-ESP	7.69	4,701	8.30	8.65	2.42	57.12	-3.57	1.03		-3.56
Lignite North	Bay Front Plant Generating	5	Mechanical Collector	4.73	10,028	2.13	3.57	6.99	-51.99	-57.07	1.57		-57.07
	Leland Olds Station	2	CS-ESP	3.81	9,193	6.72	4.02	4.05	25.65	7.29	0.95		7.29
	Antelope Valley Station	B1	SDA/FF	6.03	10,417	6.30	5.85	2.08	42.73	1.11	0.67		1.11
	Stanton Station	10	SDA/FF	7.93	2,690	8.30	7.69	8.14	11.39	-1.02	0.99		-1.02
	Stanton Station	1	CS-ESP	7.69	4,701	8.30	8.65	2.42	57.12	-3.57	1.03		-3.56
Lignite South	Limestone	LIM	CS-ESP/Wet FGD Scrubber	13.14	4,733	15.09	13.63	13.16	51.02	51.02	0.49	1.03	49.33
	Monticello	3	CS-ESP/Wet FGD Scrubber	48.43	15,735	15.61	22.23	20.55	36.44	36.44	0.64	1.03	34.24
	Big Brown	1	CS-ESP/FF (COHPAC)	32.67	15,025	13.68	30.02	29.39	14.96	-7.68	1.08	1.03	-11.79
	Monticello	1	CS-ESP/FF (COHPAC)	46.21	20,720	15.61	55.55	56.04	-19.83	-21.20	1.21	1.03	-25.40
SUBBITUMINOUS	Craig	C3	SDA/FF	0.80	9,284	2.08	0.65	0.69	13.58	35.76	0.66		35.76
	Clay Boswell	2	FF Baghouse	4.67	4,127	5.77	0.66	0.69	85.10	82.61	0.17		82.61
	Cholla	3	HS-ESP	3.04	4,148	5.46	1.22	1.08	96.46	2.28	1.36		2.28
	Craig	C1	HS-ESP/Wet FGD Scrubber	1.83	21,531	2.08	1.58	1.53	31.06	22.81	0.78	1.08	16.85
	Coronado	U1B	HS-ESP/Wet FGD Scrubber	3.10	10,356	4.95	2.13	2.23	11.46	0.86	1.15	1.08	-6.80

Table 3–4. List of Best Performing Units Under Various Ranking Scenarios (Actual Values Shown for Units with Data Quality Flag Less Than 3)

Coal Rank	Plant Name	Unit Number	Technology Control Type	Average Sampled Coal at Plant, ppm Hg	Average Sampled Coal at Plant, lb Hg/TBtu	Average Sampled Coal at Plant, ppm Cl	Average Sampled Coal at Plant, lb Cl/TBtu	Annual Average Coal at Plant, ppm Hg	Annual Average Coal at Plant, lb Hg/TBtu	Scenario 1: Average Outlet Emission, ug/dscm@ 3%O_2	Scenario 1: Average Outlet Emission, lb Hg/TBtu	Scenario 2: Average % Hg Reduction Across All Control Device(s)	Scenario 4: Average Outlet Emission, lb Hg/TBtu	Scenario 5: Average % Hg Reduction Coal to Stack	Preliminary Data Quality Flag (Max. per run)
BITUMINOUS	Mecklenburg Cogenera	GEN	SDA/FF	0.10	6.94	1,893	135,886	0.09	6.92	0.24	0.17	97.91	0.10	98.07	2.0
	SEI - Birchwood Powe	1	SCR/SDA/FF	0.11	8.76	917	73,100	0.15	11.28	0.30	0.22	97.56	0.24	97.45	2.0
	Logan Generating Pla	Gen	SCR/SDA/FF	0.18	13.08	1,500	109,006	0.17	13.35	0.27	0.19	98.53	0.27	98.51	1.0
	Intermountain	2SG	FF/Wet FGD Scrubber	0.02	1.80	200	15,394	0.04	2.96	0.44	0.32	96.62	0.28	97.48	2.0
	Salem Harbor	3	SNCR/CS-ESP	0.03	1.93	100	7,239	0.06	4.24	0.41	0.29	90.90	0.33	86.55	1.0
	Clover Power Station	2	FF/Wet FGD Scrubber	0.16	12.13	520	38,659	0.10	7.24	0.55	0.40	97.50	0.34	98.13	1.0
Lignite	Antelope Valley Stat	B1	SDA/FF	0.06	6.03	107	10,417	0.07	6.30	8.15	5.85	1.11	2.08	42.73	2.0
	Stanton Station	1	CS-ESP	0.08	7.69	50	4,701	0.09	8.30	12.06	8.65	-3.56	2.42	57.12	2.0
	Lewis & Clark	B1	PS/Wet FGD Scrubber	0.12	11.46	100	9,599	0.10	9.03	15.09	10.83	32.77	9.16	8.78	2.0
	Limestone	LIM	CS-ESP/Wet FGD Scrubber	0.14	13.14	50	4,733	0.15	15.09	19.01	13.63	49.33	13.16	51.02	2.0
	Coyote	1	SDA/FF	0.11	10.21	100	9,189	0.13	12.43	16.34	11.72	8.65	18.41	-48.67	2.0
	Big Brown	1	CS-ESP/FF (COHPAC)	0.29	32.67	133	15,025	0.13	13.68	41.85	30.02	-11.79	29.39	14.96	2.0
Lignite North	Antelope Valley Stat	B1	SDA/FF	0.06	6.03	107	10,417	0.07	6.30	8.15	5.85	1.11	2.08	42.73	2.0
	Stanton Station	1	CS-ESP	0.08	7.69	50	4,701	0.09	8.30	12.06	8.65	-3.56	2.42	57.12	2.0
	Lewis & Clark	B1	PS/Wet FGD Scrubber	0.12	11.46	100	9,599	0.10	9.03	15.09	10.83	32.77	9.16	8.78	2.0
	Coyote	1	SDA/FF	0.11	10.21	100	9,189	0.13	12.43	16.34	11.72	8.65	18.41	-48.67	2.0
Lignite South	Limestone	LIM	CS-ESP/Wet FGD Scrubber	0.14	13.14	50	4,733	0.15	15.09	19.01	13.63	49.33	13.16	51.02	2.0
	Big Brown	1	CS-ESP/FF (COHPAC)	0.29	32.67	133	15,025	0.13	13.68	41.85	30.02	-11.79	29.39	14.96	2.0
SUBBITUMINOUS	Clay Boswell	2	FF Baghouse	0.06	4.67	50	4,127	0.07	5.77	0.92	0.66	82.61	0.69	85.10	1.0
	Cholla	3	HS-ESP	0.04	3.04	50	4,148	0.06	5.46	1.70	1.22	2.28	1.08	96.46	2.5
	Presque Isle	9	HS-ESP	0.04	3.19	197	15,750	0.04	3.23	7.07	5.07	-3.63	1.26	25.73	2.0
	Craig	C1	HS-ESP/Wet FGD Scrubber	0.02	1.83	267	21,531	0.03	2.08	2.20	1.58	16.85	1.53	31.06	2.0
	Coronado	U1B	HS-ESP/Wet FGD Scrubber	0.04	3.10	117	10,356	0.06	4.95	2.97	2.13	-6.80	2.23	11.46	2.0
	Comanche	2	FF Baghouse	0.09	7.85	50	4,205	0.08	6.29	3.92	2.81	62.26	2.66	75.14	1.0
	Navajo	3	HS-ESP/Wet FGD Scrubber	0.03	2.37	150	11,767	0.04	3.06	3.81	2.73	14.87	2.72	29.42	2.0
	Sam Seymour	3	CS-ESP/Wet FGD Scrubber	0.12	10.33	20	1,685	0.09	7.12	12.89	9.25	21.28	3.72	19.13	2.0
	Rawhide	101	SDA/FF	0.07	6.15	127	10,617	0.05	3.92	10.76	7.72	32.17	7.67	-32.46	2.0
	Wyodak	BW	CS-ESP/SDA	0.04	3.44	25	2,151	0.06	5.44	10.27	7.37	41.27	8.07	-71.65	2.0

Table 3–5. List of Selected Units by Scenario Sorted by Coal Type

Coal Rank	Scenario No	Plant Name	Unit Number	Technology Control Type	Initial (Test) Hg Emission, lb/TBtu
BITUMINOUS	1	SEI - Birchwood Power Facility	1	SDA/FF	0.22
	2	SEI - Birchwood Power Facility	1	SDA/FF	0.22
	3	SEI - Birchwood Power Facility	1	SDA/FF	0.22
	4	Logan Generating Plant	Gen 1	SDA/FF	0.27
	5	Mecklenburg Cogeneration Facility	GEN 1	SDA/FF	0.10
	6	Logan Generating Plant	Gen 1	SDA/FF	0.27
Lignite	1	Lewis & Clark	B1	PS/Wet FGD Scrubber	10.83
	2	Coyote	1	SDA/FF	11.72
	4	Lewis & Clark	B1	PS/Wet FGD Scrubber	9.16
	5	Antelope Valley Station	B1	SDA/FF	2.08
	6	Limestone	LIM1	CS-ESP/Wet FGD Scrubber	13.16
Lignite North	1	Lewis & Clark	B1	PS/Wet FGD Scrubber	10.83
	2	Antelope Valley Station	B1	SDA/FF	5.85
	4	Lewis & Clark	B1	PS/Wet FGD Scrubber	9.16
	5	Lewis & Clark	B1	PS/Wet FGD Scrubber	9.16
SUBBITUMINOUS	1	Craig	C1	HS-ESP/Wet FGD Scrubber	1.58
	2	Wyodak	BW 91	CS-ESP/SDA	7.37
	3	Wyodak	BW 91	CS-ESP/SDA	7.37
	4	Presque Isle	9	HS-ESP	1.26
	5	Comanche	2	FF Baghouse	2.66
	6	Presque Isle	9	HS-ESP	1.26

Scenario 1+4: Best Performing Units as Ranked by Lowest Total Hg Emission (lb/TBtu)
Scenario 2: Best Performing Units as Ranked by Highest Percent Reduction of Mercury Across Control Device(s)
Scenario 3: Best Performing Units as Ranked by Lowest Total Hg Emission (lb/TBtu) and having at least 20% Reduction of Mercury Across Control Device(s)
Scenario 5: Best Performing Units as Ranked by Highest Percent Reduction of Mercury from Coal to Stack
Scenario 6: Best Performing Units as Ranked by Lowest Total Hg Emission (lb/TBtu) and having at least 20% Reduction of Mercury from Coal to Stack
Scenarios 1-3 are based on a combined EMF approach to emission measurement
Scenarios 4-6 are determined from coal mercury content to final emissions

4. RESULTS AND ANALYSIS OF SPECIFIC MACT FLOOR ISSUES

As described in Chapter 3, several different methods are used in calculating potential MACT floor levels. Chapter 3 presented mercury emission values resulting from the 1999 ICR-III stack tests, using three different definitions of best performing units and two different approaches for calculating emission reductions (Scenarios 1 through 6). The five best performing units for each coal rank were identified using these two measurement approaches, as well as three different definitions for best performance.

The purpose of this chapter is to present results of these scenarios for addressing variability in setting a MACT floor and standard. Section 112(d) of the Clean Air Act and court decisions on earlier standard setting suggest that the MACT floor should represent "a reasonable estimate of the performance of the 'best controlled similar unit' under the worst reasonably foreseeable circumstances," as explained in Chapter 2. The starting point for these analyses is the initial emission rate results presented in Chapter 3. While there are many sources of variability, the following methodology is used in this chapter in calculating variability in the MACT floor options:

Step 1. Present the impact of changes in the coal burned at the best performing units on mercury emissions. Two types of coal switching were considered: switching to the average coal burned at the unit in question during 1999, and switching to the average coal burned at the 95th percent worst unit (in terms of coal characteristics) in 1999. Key variables representing coal quality were mercury, chlorine, and sulfur content. This source of variability is presented in Section 4.1.

Step 2. Present the impact of uncertainty in analysis procedures on estimating mercury emissions. This source of variability is presented in Section 4.2.

Step 3. Discuss other factors that will impact MACT floor calculations qualitatively. There are many other sources of variability that may influence the calculations but that are difficult or impossible to quantify. These factors include operational considerations (such as off-peak load) and sampling and analysis factors not quantified above. This part of the analysis has not been quantified and does not affect the calculated MACT floor values. These factors are discussed in Section 4.3.

Step 4. Combine results of the testing variability with fuel switching variability to project a measure of the "worst foreseeable circumstances" at which these best performing units might operate. This result provides an estimate of a MACT floor emission rate for each of the hypothetical ranking approaches, and for each subcategory of coal-fired power plants. These combined results are presented in Section 4.4.

Variability is assessed for each of the third-best facilities identified in Chapter 3. In Chapter 3, six scenarios were evaluated for each of five coal ranks. Due to data limitations, variability was not assessed for every subcategory and every ranking scenario. In particular, no scenario involving only southern lignite was evaluated because there are less than three available facilities with acceptable data. Similarly, variability was not evaluated in other scenarios where less than three facilities were available. Finally, some scenarios had between three and five facilities with data. In these cases the third-best facility was selected for evaluation, even though it did not strictly meet the Section 112(d)(3) definition of "*the average emission limitation achieved by the best performing 5 sources*." In these cases, it is assumed that, if data were available for additional units (such that data from five units would be available), these additional units would exhibit poorer performance than the units where data are available.

4.1. Coal Variability

The purpose of coal variability analysis is to account for potential changes in source coals at the best performing units. This analysis assumes that a power-generating unit may switch to a coal with different mercury, chlorine, or sulfur levels than the coal burned during its ICR-III testing, while using the same general type of coal, such as bituminous. Actual variation at a particular unit will depend on the following factors:

- The stack tests used to determine mercury emissions in the ICR-III database each consisted of three two-hour samples. This brief sampling period may not represent typical conditions at that unit, and the emissions recorded may be even less representative of emissions at other units of similar design.

- During the course of a year, a unit could use coals from a number of coal seams. Variability typically occurs both between seams and within a seam.

The coal quality data collected by EPA in Phase 2 of the ICR-II was used to quantify this variability. Sections 4.1.1 and 4.1.2 detail the methods used for mercury and other coal properties, respectively. Specifically, the data were used the following two ways:

- In one set of variability analyses, the actual ICR-III coal mercury composition measured during the performance test at the particular unit was assumed to be replaced with a different mercury concentration coal of the same rank (selected from the ICR-II data). The other properties of the coal (such as heating value and chlorine content) were assumed to be unchanged, and the control device removal efficiency was assumed to be unaffected. The resulting emission rate is directly and linearly proportional to the change in coal mercury content. Two different approaches were used to determine the alternative coal: one which assumed the coal was represented by the average coal burned at that unit over a year, and the other assumed the alternative coal resulted from switching to coals beyond those used at the unit in question, but still within the same general coal rank.

- In a second set of variability analyses, algorithms were calculated using regression techniques to relate tested mercury emission rates to coal properties for various combinations of pollution control equipment. These algorithms were developed from all facilities in the ICR-III data set, and were developed without regard to coal rank (i.e., the same algorithm was applied to a unit burning bituminous coal and a unit burning lignite coal, if each had the same controls). The algorithms were then applied to changes in chlorine and/or sulfur changes in the coal, with mercury levels held constant. The changes in chlorine and/or sulfur content are based on the ICR-II data, in a similar manner as that described above for coal mercury content.

Some plants are expected to exhibit less variability than assumed here (such as a unit that uses coal from a single mine). Other plants may exhibit even greater variability (such as those which can burn different ranks of coal such as subbituminous or bituminous). In the former case, average mercury and chlorine levels are expected to be fairly constant from year to year, while in the latter case the levels of these elements can change even more significantly than assumed here.

The relevant ICR-II coal properties are shown in Table 4–1 with respect to coal type. To generate Table 4–1, each plant's coal data was averaged (unweighted) for the year 1999 and the grouping was made by coal rank. The ICR-II results included data for coal analyzed for the following parameters: sulfur, heat content (Btu/lb), ash, mercury, and chlorine. The distributions of annually averaged mercury and chlorine concentrations at each plant are illustrated in Figures 4–1 and 4–2, respectively. The mercury content of northern lignites differed from southern lignites by 40 percent, on average, and by more than a factor of two at the 95th percentile, and the two were considered separately for this reason.

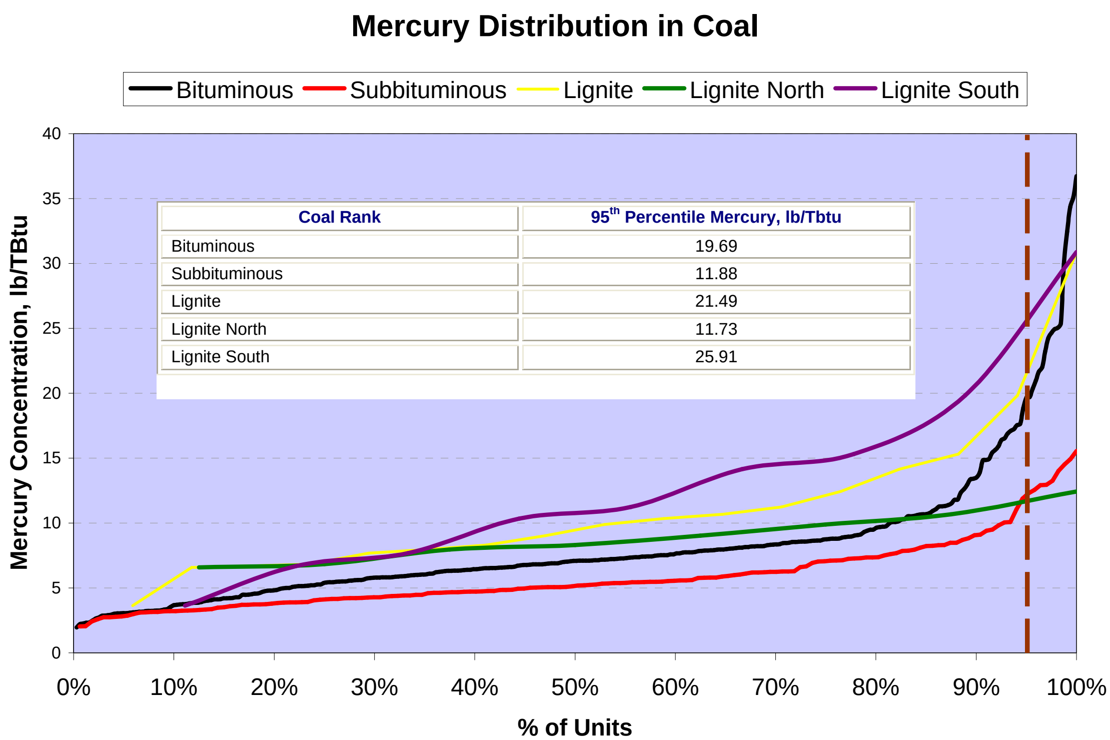
Table 4–1. 95th Percentile Annual Average Levels in "As Received" Coal from ICR-II

Coal Rank	# Plants with Data	Mercury		Chlorine		Chlorine/Sulfur
		lb/TBtu	ppm	lb/BBtu	ppm	MBtu/BBtu
Bituminous	321	19.69	0.25	17.56	210	9.11
Subbituminous	167	11.88	0.15	2.37	26	6.80
Lignite combined	17	21.49	0.20	10.15	106	8.84
Lignite north	8	11.73	0.13	9.90	105	9.47
Lignite south	9	25.91	0.25	13.60	132	8.25

Note: Ppm is approximate and is provided for reference only. Units of lb/heat content are used in all calculations. Chlorine, sulfur, and chlorine/sulfur values are the 95th percentile sorted highest to lowest (i.e., only 5 percent of the plants have an annual average value lower than the value shown).

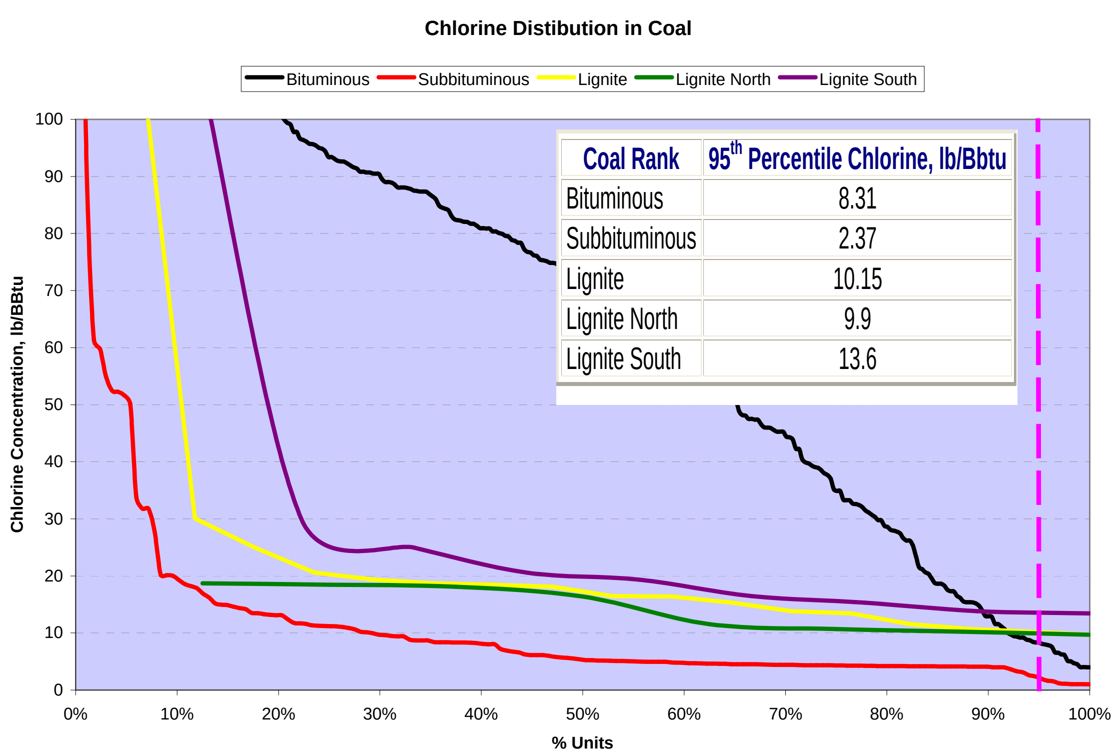
Figure 4–2 shows that many plants burning lignite or subbituminous coals have low chlorine levels (i.e., the difference between the median value and the 95th percentile value is small). Conversely, the difference between the median and 95th percentile values for bituminous coal is very significant. Therefore, the source data for bituminous coal was investigated specifically to determine if it is reasonable for a unit burning bituminous coal to burn a coal containing chlorine at the 95th percentile. Based on review of the annual average chlorine level of the plants representing the lowest chlorine levels, several of the lowest chlorine bituminous coals were found to originate in the West. It is assumed to be unreasonable for most Eastern power plants to switch to this coal source. Instead, the chlorine level used as the 95th percentile for bituminous coals is the 95th percentile level for Eastern bituminous coal production. As such, the 95th percentile value used in the analysis (reflected in Table 4–1) is 17.56 lb/BBtu, as compared to 8.31 lb/BBtu from the nationwide distribution reflected in Figure 4–2. No change was made to the chlorine-sulfur ratio because, as shown later in this chapter, this value was not used in most calculations and therefore had an insignificant impact on the possible MACT floor calculations.

Figure 4–1. Distribution of Mercury Coal Content in ICR-II Data



Coal Rank	95th Percentile Mercury, lb/Tbtu
Bituminous	19.69
Subbituminous	11.88
Lignite	21.49
Lignite North	11.73
Lignite South	25.91

Figure 4–2. Distribution of Chlorine Coal Content in ICR-II Data



Coal Rank	95th Percentile Chlorine, lb/Bbtu
Bituminous	8.31
Subbituminous	2.37
Lignite	10.15
Lignite North	9.9
Lignite South	13.6

4.1.1. Coal Mercury Variability

In this analysis, the mercury content of the coal combusted by the third-best facilities identified in Chapter 3 was varied to identify potential changes in mercury emissions at these units if the source of the coal differed from that coal used during the ICR-III performance test. Two types of variability were assessed:

- Variability within the facility. The coal used during the ICR-III testing was sampled over a short period of time (hours). The mercury composition of an alternative coal was assumed to be equal to the annual average obtained from the plant's ICR-II testing. This long-term average concentration may be higher or lower than the composition found from ICR-III.

- Variability from a different coal source. This approach postulated that a reasonable projection of a change at a best performing unit or a unit similar to a best performing unit would be based on assuming that the unit switched to a coal equivalent in mercury content to that used by the 95th percentile of average coal mercury used at plants burning coal of that rank in the ICR-II database. The 95th percentile values are shown in Table 4–1.

Emissions at the best performing units were adjusted for these types of variability by multiplying the measured emissions (from ICR-III testing) by the ratio of this "alternative coal mercury content" (based on one of the above ICR-II approaches) to the mercury content of the coal used during the ICR-III performance test. The net effect of this coal switch is presented for each of the different approaches to defining a best performing unit as discussed in Chapter 3. Results are presented in Table 4–2. An example calculation is presented in Figure 4–3.

Similarities and differences between these two alternate approaches for mercury are as follows:

- Both use the third-best facilities as the starting point.

- Both approaches calculate variability as the ratio based on the use of long-term average data (from ICR-II) and a plant's measured short-term value (from ICR-III).

- Both are intended to project long-term average emissions (i.e., annual) and are not appropriate for assessing short-term variation.

- In one approach, the intent is to measure the unit's variability based on the average coal used at the plant in 1999. In the second approach, the intent is to measure the unit's emission variability based on coals used at other plants.

Table 4–2. Variability from Coal Switching at No. 3 Facilities: Changes in Mercury Coal Composition

Coal Rank	Scenario No	Plant Name	Unit Number	Average Sampled Coal at Plant, lb Hg/TBtu	Annual Average Coal at Plant, lb Hg/TBtu	%Increase in Hg Emission, Sampled Coal to Annual Plant Average	95th percentile of Annual Average Coal at all Plants, lb Hg/TBtu	%Increase in Hg Emission, Sampled Coal to All Plants
BITUMINOUS	1	SEI - Birchwood Power Facility	1	8.76	11.28	29%	19.69	125%
	2	SEI - Birchwood Power Facility	1	8.76	11.28	29%	19.69	125%
	3	SEI - Birchwood Power Facility	1	8.76	11.28	29%	19.69	125%
	4	Logan Generating Plant	Gen 1	13.08	13.35	2%	19.69	51%
	5	Mecklenburg Cogeneration Facility	GEN 1	6.94	6.92	(0%)	19.69	184%
	6	Logan Generating Plant	Gen 1	13.08	13.35	2%	19.69	51%
Lignite	1	Lewis & Clark	B1	11.46	9.03	(21%)	21.49	88%
	2	Coyote	1	10.21	12.43	22%	21.49	111%
	4	Lewis & Clark	B1	11.46	9.03	(21%)	21.49	88%
	5	Antelope Valley Station	B1	6.03	6.30	5%	21.49	256%
	6	Limestone	LIM1	13.14	15.09	15%	21.49	64%
Lignite North	1	Lewis & Clark	B1	11.46	9.03	(21%)	11.73	2%
	2	Antelope Valley Station	B1	6.03	6.30	5%	11.73	95%
	4	Lewis & Clark	B1	11.46	9.03	(21%)	11.73	2%
	5	Lewis & Clark	B1	11.46	9.03	(21%)	11.73	2%
SUBBITUMINOUS	1	Craig	C1	1.83	2.08	14%	11.88	550%
	2	Wyodak	BW 91	3.44	5.44	58%	11.88	245%
	3	Wyodak	BW 91	3.44	5.44	58%	11.88	245%
	4	Presque Isle	9	3.19	3.23	2%	11.88	273%
	5	Comanche	2	7.85	6.29	(20%)	11.88	51%
	6	Presque Isle	9	3.19	3.23	2%	11.88	273%

Scenario 1+4: Best Performing Units as Ranked by Lowest Total Hg Emission (lb/TBtu)
Scenario 2: Best Performing Units as Ranked by Highest Percent Reduction of Mercury Across Control Device(s)
Scenario 3: Best Performing Units as Ranked by Lowest Total Hg Emission (lb/TBtu) and having at least 20% Reduction of Mercury Across Control Device(s)
Scenario 5: Best Performing Units as Ranked by Highest Percent Reduction of Mercury from Coal to Stack
Scenario 6: Best Performing Units as Ranked by Lowest Total Hg Emission (lb/TBtu) and having at least 20% Reduction of Mercury from Coal to Stack
Scenarios 1-3 are based on a combined EMF approach to emission measurement
Scenarios 4-6 are determined from coal mercury content to final emissions
Missing Scenarios result from fewer than 3 plants

Figure 4–3. Sample Calculation for Table 4–2

Scenario selected: Bituminous MACT Scenario 1
Corresponding "Number 3" facility: SEI Birchwood Power

Mercury Content of Coal Used
- Unit's data from ICR-III: 8.76 lb/TBtu
- Unit's annual average ICR-II data: 11.28 lb/TBtu
- 95^{th} Percentile value from all plants based on ICR-II: 19.69 lb/TBtu

Anticipated Changes in Mercury Emissions
- Variability likely to occur from a plant's typical activities =
  Unit's annual average ICR-II data/ Unit's data from ICR-III =
  11.28/ 8.76 = 1.29, representing an increase of 29%.

- Variability likely to occur as a result of changes in the coal used at this unit =
  95^{th} Percentile value from all plants based on ICR-II/ Unit's data from ICR-III =
  19.69/ 8.76 = 2.25, representing an increase of 125%.

4.1.2. *Coal Chlorine and Sulfur Variability*

Coal chlorine content, and possibly other coal characteristics such as sulfur, are believed to influence the performance of pollution control equipment in reducing mercury emissions. For example, coals with lower chlorine content generally are associated with lower levels of mercury capture, for a given class of control equipment. "Worst-case" coal was determined to be one with low chlorine, or with a disadvantaging chlorine-to-sulfur ratio, as evident from the algorithms described below.

This analysis evaluated the ICR-III data to identify statistical correlations between coal characteristics and mercury removal by various classes of control equipment. A detailed description of those statistical analyses is presented in Appendix G. These analyses resulted in regression-based algorithms for mercury capture by each class of control technology as a function of chlorine and/or sulfur content (but not as a function of coal rank). The "best" algorithms for each control device are summarized in Table 4–3.

Table 4–3. Predictive Algorithms for Mercury Reduction (-ln(100%-% Reduction))

Control Type	Equation	Function	R-Squared Value
CS-ESP	Model 3	= 3.929E-06*(Cl/S) – 0.0310	0.66
CS-ESP/ Wet FGD	Model 1	= 0.27149*ln(Cl, lb/TBtu) - 1.8529	0.74
FF Baghouse	Model 1	= 0.29335*ln(Cl, lb/TBtu) – 0.8194	0.50
HS-ESP	Model 2	= 3.816E-06*(Cl, lb/TBtu) – 0.0759	0.69
HS-ESP/ Wet FGD	Model 1	= 0.29952*ln(Cl, lb/TBtu) - 2.7019	0.75
PS/ Wet FGD	No valid algorithm; poor fit		
SDA/ FF	Model 1	= 1.22628*ln(Cl, lb/TBtu) - 10.7111	0.89

Model1: -Ln(1 - Percent Reduction) as a function of Ln(Chlorine)
Model2: -Ln(1 - Percent Reduction) as a function of Chlorine
Model3: -Ln(1 - Percent Reduction) as a function of Ratio Chlorine to Sulfur
Model4: -Ln(1 - Percent Reduction) as a function of Ln(ratio of Chlorine to Sulfur)
All Ln notations are natural logarithms. Additional detail regarding the algorithms is presented in Appendix G. For each control type, four algorithms were determined: two based on chlorine only, and two based on chlorine/sulfur (determined on a ln-ln scale, and a ln-linear scale). In most cases, Model 1 was found to have the highest R^2 (best fit).

The algorithms were then used to project how emissions might vary at the best performing units if the unit changed to a coal with other characteristics. These algorithms were applied in the following manner:

- First, the third-best unit for each scenario/coal type was selected. These are the same units identified for the mercury variability analysis in Table 4–2.

- The control device at the third-best facility was identified. Appropriate algorithms for this control device were selected from Table 4–3. The algorithms calculate percent reduction of mercury versus coal property.

- The percent reduction was calculated using the average chlorine and sulfur levels measured in ICR-III. This percent reduction refers to an "across control" reduction.

- The same algorithm was applied in the following two ways: using the facility's average chlorine and sulfur levels from its ICR-II data, and using the 95 percent lowest chlorine and sulfur levels from all plants from the ICR-II database (with the correction explained earlier for bituminous coals).

- The mercury pass-through (100-percent reduction) obtained using the facility's ICR-II data was divided by the 100-percent reduction value calculated using the ICR-III data. The ratio of these resulting percentages reflects plant variability based on the average coal used at the plant in 1999.

- The mercury pass through (100-percent reduction) obtained using the 95 percent ICR-II data was divided by the 100-percent reduction value calculated using the ICR-III data. The ratio of these resulting percentages reflects the variability from coal switching based on the second alternative for evaluating coal switching.

- If an algorithm was not available for a given control device present at the third-best unit, no analysis was conducted.

Figure 4–4 illustrates the application of the algorithm. The results of this analysis are described in Section 4.1.3. Intermediate calculations are presented in Appendix G. Sample calculations for some of the values in Table 4–5 are given in Appendix D.

4.1.3. *Overall Effect of Coal Switching*

Table 4–4 presents the impact of coal switching for each of the analyses presented in Sections 4.1.1 and 4.1.2. It is important to note that this analysis did not assume that a unit would use both the worst coal from a mercury content perspective (reflected in Table 4–2) and from a control technology perspective (reflected in Appendix G). Whichever approach led to the larger emission variation was used to project emissions for the MACT floor, and the other variability consideration was ignored.

In Table 4–4, the ICR emission rates for each scenario are presented along with two different overall impacts on mercury emissions from coal switching. The first coal-switching impact (in the middle of the table) accounts for a plant changing the source of its coal to a worst coal (defined as the average coal at the 95^{th} percentile worst plant, based on ICR-II data). The second coal-switching impact (the final column of the table) accounts for coal-switching variability by using the plant's average coal for 1999 (as determined from ICR-II). These values present a range of possible methods of accounting for variability in the feed coal, and show their contributions to possible MACT floor values.

Figure 4–4. Application of Algorithm

Scenario selected: Bituminous MACT Scenario 1
Corresponding "Number 3" facility: SEI Birchwood Power
Control device present at facility: SDA/ fabric filter
Corresponding algorithm for control device:

-ln(100%-% Reduction) = 1.22628*ln(Cl, lb/TBtu) - 10.7111

Unit's data from ICR-III: 73,100 lb/TBtu
Unit's annual average ICR-II data: 74,646 lb/TBtu
95^{th} percentile value from all plants based on ICR-II: 17,560 lb/TBtu

Calculate algorithm based on the facility's ICR-III data:

-ln(100%-% Reduction) = 1.22628*ln(Cl, lb/TBtu) - 10.7111
-ln(100%-% Reduction) = 1.22628*11.1996 - 10.7111
-ln(100%-% Reduction) = 3.0227
100%-% Reduction = 0.0487= 4.87%
% Reduction = 0.9513 = 95.13%

Repeating the calculation for the remaining coal properties gives the following results (these are given in Appendix G):

Source of Coal Data	Chlorine Value lb/TBtu	% Reduction
Plant ICR-III	73,100	95%
Plant ICR-II (average)	74,646	95%
95^{th} Percentile ICR-II	17,560	72%

The resulting variability values are as follows (these are given in Table 4-6):

Variability	Expression	Data	% Increase
Plant Variability	(100% - % Reduction) of: Plant ICR-II (average) / Plant ICR-III	(1-0.9513)/ (1-0.9526)	(3%)
Industry-Wide Coal Variability	(100% - % Reduction) of : 95^{th} Percentile ICR-II/ Plant ICR-III	(1-0.7202)/ (1-0.9526)	475%

Table 4–4. Variability from Coal Switching at No. 3 Facilities: Coal Substitution (Changes in Mercury, Chlorine, and Sulfur Properties) Resulting in Highest Variability

Coal Rank	Scenario No	Plant Name	Unit Number	Technology Control Type	Initial (Test) Hg Emission, lb/TBtu	%Increase in Hg Emission, Sampled Coal to All Plants (Cl & S Effects)	%Increase in Hg Emission, Sampled Coal to All Plants (Hg Effects)	Calculated Hg Emission with Variability at All Plants, lb/TBtu	%Increase in Hg Emission, Sampled Coal to Annual Plant Average (Cl & S Effects)	%Increase in Hg Emission, Sampled Coal to Annual Plant Average (Hg Effects)	Calculated Hg Emission with Annual Plant Variability (Single Plant), lb/TBtu
BITUMINOUS	1	SEI - Birchwood Power Facility	1	SDA/FF	0.22	475%	125%	1.25	(3%)	29%	0.28
	2	SEI - Birchwood Power Facility	1	SDA/FF	0.22	475%	125%	1.25	(3%)	29%	0.28
	3	SEI - Birchwood Power Facility	1	SDA/FF	0.22	475%	125%	1.25	(3%)	29%	0.28
	4	Logan Generating Plant	Gen 1	SDA/FF	0.27	838%	51%	2.56	(7%)	2%	0.28
	5	Mecklenburg Cogeneration Facility	GEN 1	SDA/FF	0.10	1129%	184%	1.27	26%	(0%)	0.13
	6	Logan Generating Plant	Gen 1	SDA/FF	0.27	838%	51%	2.56	(7%)	2%	0.28
Lignite	1	Lewis & Clark	B1	PS/Wet FGD Scrubber	10.83		88%	20.31		(21%)	8.53
	2	Coyote	1	SDA/FF	11.72	(11%)	111%	24.68	(2%)	22%	14.27
	4	Lewis & Clark	B1	PS/Wet FGD Scrubber	9.16		88%	17.19		(21%)	7.22
	5	Antelope Valley Station	B1	SDA/FF	2.08	3%	256%	7.41	2%	5%	2.17
	6	Limestone	LIM1	CS-ESP/Wet FGD Scrubber	13.16		64%	21.53		15%	15.11
Lignite North	1	Lewis & Clark	B1	PS/Wet FGD Scrubber	10.83		2%	11.08		(21%)	8.53
	2	Antelope Valley Station	B1	SDA/FF	5.85	6%	95%	11.37	2%	5%	6.11
	4	Lewis & Clark	B1	PS/Wet FGD Scrubber	9.16		2%	9.38		(21%)	7.22
	5	Lewis & Clark	B1	PS/Wet FGD Scrubber	9.16		2%	9.38		(21%)	7.22
SUBBITUMINOUS	1	Craig	C1	HS-ESP/Wet FGD Scrubber	1.58	94%	550%	10.26	70%	14%	2.67
	2	Wyodak	BW 91	CS-ESP/SDA	7.37		245%	25.45		58%	11.66
	3	Wyodak	BW 91	CS-ESP/SDA	7.37		245%	25.45		58%	11.66
	4	Presque Isle	9	HS-ESP	1.26	5%	273%	4.69	3%	2%	1.29
	5	Comanche	2	FF Baghouse	2.66	2%	51%	4.03	(43%)	(20%)	2.13
	6	Presque Isle	9	HS-ESP	1.26	5%	273%	4.69	3%	2%	1.29

Scenario 1+4: Best Performing Units as Ranked by Lowest Total Hg Emission (lb/TBtu)
Scenario 2: Best Performing Units as Ranked by Highest Percent Reduction of Mercury Across Control Device(s)
Scenario 3: Best Performing Units as Ranked by Lowest Total Hg Emission (lb/TBtu) and having at least 20% Reduction of Mercury Across Control Device(s)
Scenario 5: Best Performing Units as Ranked by Highest Percent Reduction of Mercury from Coal to Stack
Scenario 6: Best Performing Units as Ranked by Lowest Total Hg Emission (lb/TBtu) and having at least 20% Reduction of Mercury from Coal to Stack
Scenarios 1-3 are based on a combined EMF approach to emission measurement
Scenarios 4-6 are determined from coal mercury content to final emissions
Missing Scenarios result from fewer than 3 plants

4.2. Analysis Variability

Analysis variability includes the variability within the coal and flue gas test methods. In this evaluation, the following types of analytical variability are accounted for:

- The variability in the OH analysis method caused by imprecision in the test method.

- Analogous variability in the coal-test method.

4.2.1. Ontario-Hydro Variability

During the ICR-III testing program, the OH method was in draft form. Following completion of these tests, the method became a published ASTM International method (ASTM D 6784-02). The ASTM method includes reproducibility data based on replicate sampling and analysis of 12 runs (therefore, these data account for variability in both sampling and analysis). It should be noted, however, that the data do not reflect test variability that derives from not following the test method. Such unaccounted variability can occur from not sampling isokinetically, or not sampling in a laminar flow environment. These reproducibility data are used here to estimate variability associated with the OH method. The data shows that there is a greater degree of variability at lower measured concentrations. Using regression analysis, this variability was quantified for all concentrations in the ICR-III measurements. Details regarding this procedure are presented in Appendix E. The variability [expressed as relative standard deviation (RSD)] was found to fit the following equation:

$RSD = 0.5001 * [\text{Mean Hg } (ug/Nm^3)]^{-0.571}$ $R^2 = 0.92$

The 95 percent upper confidence limit (UCL) is related to RSD in the following manner:

STD (standard deviation) = Mean * RSD

UCL (upper confidence limit) = Mean $+Z_{0.95}$*STD where $Z_{0.95}$=1.645 (one-tailed 95 percent confidence coefficient)

Results are shown in Table 4–5 for the facilities evaluated under the various ranking scenarios. An example calculation for Table 4–5 is presented in Figure 4–5.

Table 4–5. Variability of Ontario-Hydro Method

Coal Rank	Scenario No	Plant Name	Unit Number	Technology Control Type	Initial (Test) Hg Emission, lb/TBtu	Corresponding Baseline Hg Emission, ug/Nm3	Calculated RSD	Standard Dev. (ug/Nm3)	Calculated 95% CL (ug/Nm3)	Calculated Hg Emission (OH Variability), lb/TBtu
BITUMINOUS	1	SEI - Birchwood Power Facility	1	SDA/FF	0.22	0.29	1.02	0.29	0.77	0.58
	2	SEI - Birchwood Power Facility	1	SDA/FF	0.22	0.29	1.02	0.29	0.77	0.58
	3	SEI - Birchwood Power Facility	1	SDA/FF	0.22	0.29	1.02	0.29	0.77	0.58
	4	Logan Generating Plant	Gen 1	SDA/FF	0.27	0.36	0.90	0.32	0.89	0.67
	5	Mecklenburg Cogeneration Facility	GEN 1	SDA/FF	0.10	0.14	1.56	0.21	0.49	0.37
	6	Logan Generating Plant	Gen 1	SDA/FF	0.27	0.36	0.90	0.32	0.89	0.67
Lignite	1	Lewis & Clark	B1	PS/Wet FGD Scrubber	10.83	14.32	0.11	1.57	16.89	12.77
	2	Coyote	1	SDA/FF	11.72	15.50	0.10	1.62	18.17	13.74
	4	Lewis & Clark	B1	PS/Wet FGD Scrubber	9.16	12.12	0.12	1.46	14.52	10.98
	5	Antelope Valley Station	B1	SDA/FF	2.08	2.75	0.28	0.77	4.02	3.04
	6	Limestone	LIM1	CS-ESP/Wet FGD Scrubber	13.16	17.41	0.10	1.70	20.21	15.28
Lignite North	1	Lewis & Clark	B1	PS/Wet FGD Scrubber	10.83	14.32	0.11	1.57	16.89	12.77
	2	Antelope Valley Station	B1	SDA/FF	5.85	7.73	0.16	1.20	9.71	7.34
	4	Lewis & Clark	B1	PS/Wet FGD Scrubber	9.16	12.12	0.12	1.46	14.52	10.98
	5	Lewis & Clark	B1	PS/Wet FGD Scrubber	9.16	12.12	0.12	1.46	14.52	10.98
SUBBITUMINOUS	1	Craig	C1	HS-ESP/Wet FGD Scrubber	1.58	2.09	0.33	0.69	3.21	2.43
	2	Wyodak	BW 91	CS-ESP/SDA	7.37	9.75	0.14	1.33	11.93	9.02
	3	Wyodak	BW 91	CS-ESP/SDA	7.37	9.75	0.14	1.33	11.93	9.02
	4	Presque Isle	9	HS-ESP	1.26	1.66	0.37	0.62	2.69	2.03
	5	Comanche	2	FF Baghouse	2.66	3.52	0.24	0.86	4.93	3.73
	6	Presque Isle	9	HS-ESP	1.26	1.66	0.37	0.62	2.69	2.03

Scenario 1+4: Best Performing Units as Ranked by Lowest Total Hg Emission (lb/TBtu)
Scenario 2: Best Performing Units as Ranked by Highest Percent Reduction of Mercury Across Control Device(s)
Scenario 3: Best Performing Units as Ranked by Lowest Total Hg Emission (lb/TBtu) and having at least 20% Reduction of Mercury Across Control Device(s)
Scenario 5: Best Performing Units as Ranked by Highest Percent Reduction of Mercury from Coal to Stack
Scenario 6: Best Performing Units as Ranked by Lowest Total Hg Emission (lb/TBtu) and having at least 20% Reduction of Mercury from Coal to Stack

Scenarios 1-3 are based on a combined EMF approach to emission measurement
Scenarios 4-6 are determined from coal mercury content to final emissions
Missing Scenarios result from fewer than 3 plants

Figure 4–5. Sample Calculation for Table 4–5

Scenario selected: Bituminous MACT Scenario 1
Corresponding 'Number 3' facility: SEI Birchwood Power

Initial Mercury Emissions

- Expressed in lb/TBtu: 0.22 lb/TBtu
- Estimated corresponding stack gas concentration (e.g., using F-factor): 0.29 ug/Nm3

Variability

- Calculated RSD using equation in Section 4.3.1:
  $RSD = 0.5001 * [\text{Mean Hg } (ug/Nm^3)]^{-0.571}$ $R^2 = 0.9222$
  RSD = 1.02 (i.e., 102%)

- Calculated standard deviation = Mean * RSD = 0.29 ug/Nm3 * 1.02 = 0.29 ug/Nm3
- Calculated upper confidence limit = Mean $+Z_{0.95}$*STD where $Z_{0.95}=1.645$
- Calculated upper confidence limit = 0.29 ug/Nm3 + 1.645*0.29 = 0.77 ug/Nm3

Calculated Mercury Emissions with Variability

- Stack gas concentration: 0.77 ug/Nm3
- Expressed in lb/TBtu (e.g., using F-factor): 0.58 lb/TBtu

- Variability likely to occur from a plant's typical activities =
  Unit's annual average ICR-II data/ Unit's data from ICR-III =
  11.28/ 8.76 = 1.29, representing an increase of 29%.

- Variability likely to occur as a result of changes in the coal used at this unit =
  95^{th} Percentile value from all plants based on ICR-II/ Unit's data from ICR-III =
  19.69/ 8.76 = 2.25, representing an increase of 125%.

4.2.2 *Coal Analysis Variability*

An additional source of variability occurs with coal measurements. Errors in analysis result in deviations between the coal's reported mercury value and its "true" value (which is never known with absolute certainty). Using laboratory precision data, an estimate of this variability was calculated. Variability was found to increase at lower concentrations, as shown above with the gas-phase measurements. Details regarding the procedure used in estimating variability are presented in Appendix F. The variability was found to fit the following equation for relative confidence limit (RCL):

$RCL = 0.0758 + 36392.661 * [\text{Mean Hg } (ng/g)]^{-3.365}$ $R^2 = 0.98$

The 95 percent upper confidence limit (UCL) is related to RCL in the following manner:

STD (standard deviation) = Mean * RCL

UCL (upper confidence limit) = Mean $+Z_{0.95}$*STD where $Z_{0.95}=1.645$ (one-tailed 95 percent confidence coefficient)

This variability is for the analysis only, and does not reflect sampling variability. Results are shown in Table 4–6 for the facilities evaluated under the various ranking scenarios.

Additional analysis variability may result from the use of different mercury analysis methods for both the ICR-II and ICR-III coal analyses among the various units. Many different analysis methods are identified as being used for both the ICR-II and ICR-III analyses of mercury in feed coal. However, most analyses were conducted using cold vapor atomic absorption methods, and therefore are expected to provide somewhat consistent results.

At higher mercury levels, the method precision is fairly good (within ten percent) which would have only a minor effect on the results. The above equation is considered particularly uncertain for coal concentrations below the lowest mercury value for which source data are available (i.e., 37 ppb). None of the evaluated facilities had levels of mercury significantly less than this value.

Coal variability is potentially relevant in Scenarios 4, 5, and 6, in which emission reductions are calculated at the difference between final emissions (measured using the OH method) and coal mercury (measured using the coal analysis approach discussed in this subsection). Because variability in these scenarios due to the OH method was consistently greater than variability due to coal analysis, the coal analysis became a relatively insignificant source of uncertainty. As a result, coal test method variability does not contribute to the overall variability results calculated in the remainder of this report.

Table 4–6. Variability of Coal Analysis

Coal Rank	Scenario No	Plant Name	Unit Number	Technology Control Type	Initial (Test) Hg Emission, lb/TBtu	Average Sampled Coal at Plant, ng/g	Calculated RSD(ng/g)	Standard Dev. (Coal)	Calculated 95% CL, ng/g	Calculated Hg Emission, lb/TBtu
BITUMINOUS	1	SEI - Birchwood Power Facility	1	SDA/FF	0.22	110.00	0.08	8.88	124.61	0.25
	2	SEI - Birchwood Power Facility	1	SDA/FF	0.22	110.00	0.08	8.88	124.61	0.25
	3	SEI - Birchwood Power Facility	1	SDA/FF	0.22	110.00	0.08	8.88	124.61	0.25
	4	Logan Generating Plant	Gen 1	SDA/FF	0.27	180.00	0.08	13.81	202.72	0.31
	5	Mecklenburg Cogeneration Facility	GEN 1	SDA/FF	0.10	96.67	0.08	8.06	109.93	0.12
	6	Logan Generating Plant	Gen 1	SDA/FF	0.27	180.00	0.08	13.81	202.72	0.31
Lignite	1	Lewis & Clark	B1	PS/Wet FGD Scrubber	10.83	119.33	0.08	9.49	134.95	12.24
	2	Coyote	1	SDA/FF	11.72	110.67	0.08	8.92	125.34	13.27
	4	Lewis & Clark	B1	PS/Wet FGD Scrubber	9.16	119.33	0.08	9.49	134.95	10.36
	5	Antelope Valley Station	B1	SDA/FF	2.08	62.00	0.11	6.80	73.18	2.45
	6	Limestone	LIM1	CS-ESP/Wet FGD Scrubber	13.16	139.00	0.08	10.85	156.84	14.85
Lignite North	1	Lewis & Clark	B1	PS/Wet FGD Scrubber	10.83	119.33	0.08	9.49	134.95	12.24
	2	Antelope Valley Station	B1	SDA/FF	5.85	62.00	0.11	6.80	73.18	6.90
	4	Lewis & Clark	B1	PS/Wet FGD Scrubber	9.16	119.33	0.08	9.49	134.95	10.36
	5	Lewis & Clark	B1	PS/Wet FGD Scrubber	9.16	119.33	0.08	9.49	134.95	10.36
SUBBITUMINOUS	1	Craig	C1	HS-ESP/Wet FGD Scrubber	1.58	22.67	1.08	24.39	62.79	4.37
	2	Wyodak	BW 91	CS-ESP/SDA	7.37	40.00	0.22	8.95	54.72	10.08
	3	Wyodak	BW 91	CS-ESP/SDA	7.37	40.00	0.22	8.95	54.72	10.08
	4	Presque Isle	9	HS-ESP	1.26	40.00	0.22	8.95	54.72	1.72
	5	Comanche	2	FF Baghouse	2.66	93.33	0.08	7.87	106.28	3.03
	6	Presque Isle	9	HS-ESP	1.26	40.00	0.22	8.95	54.72	1.72

Scenario 1+4: Best Performing Units as Ranked by Lowest Total Hg Emission (lb/TBtu)
Scenario 2: Best Performing Units as Ranked by Highest Percent Reduction of Mercury Across Control Device(s)
Scenario 3: Best Performing Units as Ranked by Lowest Total Hg Emission (lb/TBtu) and having at least 20% Reduction of Mercury Across Control Device(s)
Scenario 5: Best Performing Units as Ranked by Highest Percent Reduction of Mercury from Coal to Stack
Scenario 6: Best Performing Units as Ranked by Lowest Total Hg Emission (lb/TBtu) and having at least 20% Reduction of Mercury from Coal to Stack
Scenarios 1-3 are based on a combined EMF approach to emission measurement
Scenarios 4-6 are determined from coal mercury content to final emissions
Missing Scenarios result from fewer than 3 plants

4.3. Additional Sampling and Operational Variability

In addition to the sources of variation in emissions presented above, there are additional factors that could change emissions at the best performing units. These include:

- *Sampling Variability.* Emission tests include procedural errors that are often unavoidable given the practical challenges of working with real operating power plants, which have imperfect access to test locations, and immutable design features that may not comport with ideal test protocols.

- *Operational Variability.* Even a smoothly operating unit has minor variations in flow rates, feed conditions, and other factors over time. In addition, unit-to-unit variations can significantly affect emissions even for two similar units, such as a pulverized coal boiler and an electrostatic precipitator (ESP) control burning bituminous coal. Finally, short-term performance tests, such as those reported pursuant to ICR-III, are conducted under full load conditions, and may not reflect emission reductions under partial load.

This section addresses the above areas of uncertainty. Unfortunately, not all sources of variability were quantified for this report. This report did not conduct an exhaustive assessment of all parameters that might contribute additional variation to future emissions. These factors were either considered secondary to the primary factors that were evaluated, or largely lacking in supporting data on which quantitative estimates could be made. Such factors are discussed further in this section.

4.3.1. Sampling Variability

Sampling variability is the variation in results of coal sampling or stack-test sampling. In some units, additional mercury analyses data were collected during the stack tests, such as fly ash measurements (useful for mass balance calculations) and continuous emissions monitoring systems (CEMS) for mercury (useful for comparing stack measurements). Evaluation of the data provides an indication of confidence. If multiple measurements are in agreement, then there is greater confidence in the results. However, in cases where there is variation, it is difficult to identify which particular measurement is subject to the greatest error.

The OH method identifies EPA Method 1—Sample and Velocity Traverses for Stationary Sources—as the standard for locating the sampling ports used in the conducting of speciated and total flue gas mercury measurements at coal-fired stationary sources. The promulgated method has the stated purpose of providing "guidance for the selection of sampling ports and traverse points at which sampling air pollutants will be performed… ." Method 1 is intended to provide representative measurement of pollutant emissions and includes requirements regarding sampling locations and their proximity to upstream and downstream flow disturbances. Method 1 is not acceptable for use when flow is cyclonic or swirling or when the stack cross section is smaller than 0.071 m^2.

Method 1 exists primarily because flow within a stack or ductwork can be unevenly distributed. Sampling at locations where flue gas is not homogeneous can result in erroneous measurements of flue gas constituents. Power plants are usually designed to minimize cost and space requirements, and flue gas flow patterns within the resulting ductwork often deviate from desired uniform and unidirectional conditions. Flow separation, reverse flow, rolling flow, and vortex or cyclonic flow can occur along major flue runs.[7] Because of the potential uncertainty associated with measuring nonuniform flow, Method 1 explicitly notes that its requirements be considered before construction of a new facility from which emissions are to be measured.

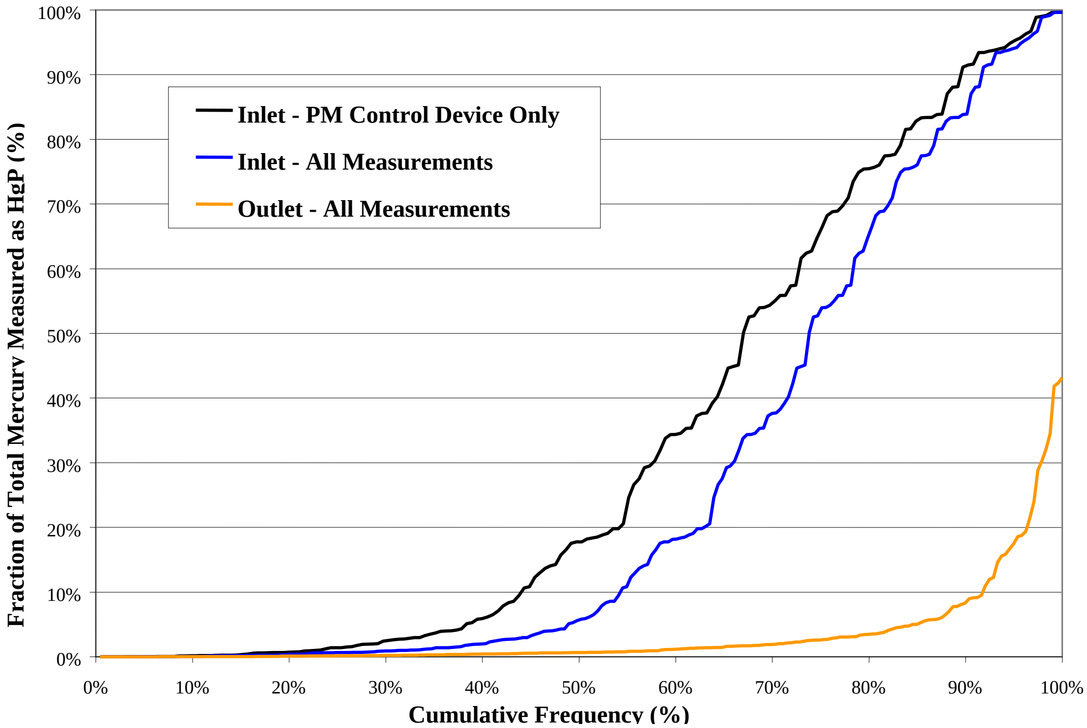
[7] Singer, J.G. edit., Combustion Fossil Power, Fourth Edition, Combustion Engineering, Inc. Windsor, Connecticut, 1991.

Many units participating in ICR Phase III sampling were unable to provide sampling locations that met Method 1 criteria. EPA waived the requirement that sampling locations meet Method 1 criteria "because of the nature of the constituent investigated." In circumstances where ductwork leading to the control device inlet did not meet Method 1 criteria, EPA allowed that sampling be performed at the most accessible inlet location without conducting the three-dimensional flow testing that may be needed at several inlet locations to find a suitable location. EPA attested that the flow testing was not necessary "because (a) mercury is primarily in the gaseous phase and is not impacted by uncertainties in the gas flow and the isokinetic sampling rate, and (b) stratification of mercury species is not expected." In those circumstances where multiple ducts were found, sampling at a single duct was considered acceptable as long as appropriate process conditions were monitored for all ducts. If large ducts (depths greater than 16 feet) were sampled, sample traversing to a depth of only 16 feet was permitted. The latter two conditions were considered acceptable because mercury species were not expected to stratify within the ductwork. In all cases, specifics of the testing procedures were to be included within the site test plan and in the final emission test report.[8]

The assumption that strict adherence with Method 1 criteria was not necessary was based primarily on the supposition that flue gas mercury concentration would not vary throughout the duct cross section. While it may be reasonable to assume that gas-phase mercury (Hg^{++}, Hg^{0}) is homogeneously distributed, even in a stratified gas stream, it may not be true for particulate-bound mercury (HgP). In situations where particulate mercury is a significant fraction of the total flue gas mercury concentration, sampling inconsistent with Method 1 criteria may not provide a representative sample and some bias may exist for both speciated fractions and total mercury concentration. Figure 4–6 provides cumulative frequency curves of the particulate fraction of the total mercury concentration for inlet and outlet measurements. Because many of the measurements were conducted downstream of the particulate collection device, Figure 4–6 also includes a cumulative frequency curve for the inlet to particulate collection devices only, the configuration where the particulate mass loading would be highest.

[8] EPA/Research Triangle Institute Electric Utility Steam Generating Unit Mercury Emissions Information Collection Effort Website Phase III FAQ (http://utility.rti.org/part3/faqP3.cfm).

Figure 4–6. HgP Fraction of Total Mercury Concentration for ICR Phase III Ontario-Hydro Measurements[9]



As can be seen in Figure 4–6, HgP can constitute a significant fraction of the total mercury. If stratification of flue gas flow is present, bias to the total measured mercury concentration may result for sample locations that do not conform to Method 1 criteria. Of the units that are considered for the best five analysis, 14 units reported problems meeting Method 1 criteria in their speciated mercury test reports.[10]

4.3.2. *Operational Variability*

Operational variability includes within-plant and plant-to-plant variations affecting mercury emissions and collection efficiency. These variations were not explicitly quantified. Factors include the following:

- Variation in plant operation (startup, shutdown, malfunction, load following operation, variation in ambient conditions, or other factors).

- Variation in the form of mercury generated by boilers. The form of mercury generated by the units (such as particulate, elemental, or oxidized) greatly influences the overall mercury collection efficiency. As determined from the control device inlet measurements, the distribution of the mercury species formed can have great variability for a given coal type.

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[9] EPA Extracted ICR Data, downloaded from EPA Technology Transfer Network Air Toxics Website (http://www.epa.gov/ttn/atw/combust/utiltox/rawdata1.xls). Does not include the 2 IGCC units and 1 invalid test result for Leland Olds Unit 2.
[10] Test reports downloaded from EPA Technology Transfer Network Air Toxics Website (http://www.epa.gov/ttn/atw/combust/utiltox/mercury.html).

4.4. *Combining Uncertainties*

In this section, the results of the coal-switching variability analyses described in Section 4.1 are combined with the measurement variability analyses described in Section 4.2.2. Specifically, the following types of variability were assessed in Sections 4.1 and 4.2:

- Changes in mercury content of coal, which directly changes mercury emissions (shown in Table 4–2).
- Changes in chlorine content of coal, which changes control efficiency and therefore mercury emissions (shown in Table 4–4).
- Variability and uncertainty associated with the OH method (shown in Table 4–5).
- Variability and uncertainty associated with mercury-in-coal analysis methods (shown in Table 4–6).

While other sources of variability were noted in Section 4.3, these additional sources were not quantified. The purpose of this section is to present the results of combining the above uncertainties in various ways. Further evaluation of variability associated with coal measurement is not included here because the variability is small and its impact is best included during the unit selection and ranking step (i.e., deciding the five best units for a given scenario).

Section 4.1.3 presents an analysis of variability of the mercury and chlorine coal levels, while Section 4.2 presents an analysis of variability of the gas measurements. The combined effect of these sources of variability is not to simply add their contributions; instead the combined effect is lower than the sum of each component. For example, as a result of coal switching, mercury levels in the stack gas will increase, leading to lower variability with the OH method.

Tables 4–7 and 4–8 calculate the impacts on the possible MACT floor values for each of the six evaluated scenarios as a result of this combined uncertainty. Each of the two tables addresses each of the two scenarios described in Section 4.1: switching to the 95th percentile worst coal, and use of the plant's historical average data. In each table the starting point is the adjustment in emissions calculated from the coal-switching analysis in Section 4.1.3. Next, this is converted to an estimated mercury concentration and the associated relative standard deviation, standard deviation, and upper confidence limit is determined using the same equations identified in Section 4.2. Finally, this stack gas concentration is converted back to a MACT floor emission rate.

Table 4–9 presents the raw ICR-III test results and sampling uncertainty, and summarizes the range of MACT floor values for each scenario based on the combined sources of uncertainty presented in this chapter. The values presented are as follows:

- Emissions reflecting possible changes in the mercury or chlorine level of the coal (based on changing to the 95th percentile worst coal), and additional effects of the OH method variability.
- Emissions reflecting possible changes in the mercury or chlorine level of the coal using the plant's historical annual average data, and additional effects of the OH method variability.

Table 4–7. Variability of Ontario-Hydro Method Applied to Coal Switching: Calculated from 95th Percentile Annual Average Coal at All Plants

Coal Rank	Scenario No	Plant Name	Unit Number	Technology Control Type	Calculated Hg Emission with Variability due to Coal Switching, lb/TBtu	Corresponding Hg Emission with Variability due to Coal Switching, ug/Nm3	Calculated RSD	Standard Dev. (ug/Nm3)	Calculated 95%CL (ug/Nm3)	Calculated Hg Emission with Variability due to Coal Switching, including Analytical Variability, lb/TBtu
BITUMINOUS	1	SEI - Birchwood Power Facility	1	SDA/FF	1.25	1.65	0.38	0.62	2.67	2.02
	2	SEI - Birchwood Power Facility	1	SDA/FF	1.25	1.65	0.38	0.62	2.67	2.02
	3	SEI - Birchwood Power Facility	1	SDA/FF	1.25	1.65	0.38	0.62	2.67	2.02
	4	Logan Generating Plant	Gen 1	SDA/FF	2.56	3.39	0.25	0.84	4.77	3.61
	5	Mecklenburg Cogeneration Facility	GEN 1	SDA/FF	1.27	1.67	0.37	0.62	2.70	2.04
	6	Logan Generating Plant	Gen 1	SDA/FF	2.56	3.39	0.25	0.84	4.77	3.61
Lignite	1	Lewis & Clark	B1	PS/Wet FGD Scrubber	20.31	26.86	0.08	2.05	30.23	22.86
	2	Coyote	1	SDA/FF	24.68	32.64	0.07	2.23	36.31	27.45
	4	Lewis & Clark	B1	PS/Wet FGD Scrubber	17.19	22.74	0.08	1.91	25.88	19.57
	5	Antelope Valley Station	B1	SDA/FF	7.41	9.80	0.14	1.33	11.99	9.07
	6	Limestone	LIM1	CS-ESP/Wet FGD Scrubber	21.53	28.48	0.07	2.10	31.94	24.15
Lignite North	1	Lewis & Clark	B1	PS/Wet FGD Scrubber	11.08	14.66	0.11	1.58	17.26	13.05
	2	Antelope Valley Station	B1	SDA/FF	11.37	15.04	0.11	1.60	17.67	13.36
	4	Lewis & Clark	B1	PS/Wet FGD Scrubber	9.38	12.41	0.12	1.47	14.83	11.22
	5	Lewis & Clark	B1	PS/Wet FGD Scrubber	9.38	12.41	0.12	1.47	14.83	11.22
SUBBITUMINOUS	1	Craig	C1	HS-ESP/Wet FGD Scrubber	10.26	13.57	0.11	1.53	16.09	12.17
	2	Wyodak	BW 91	CS-ESP/SDA	25.45	33.66	0.07	2.26	37.38	28.26
	3	Wyodak	BW 91	CS-ESP/SDA	25.45	33.66	0.07	2.26	37.38	28.26
	4	Presque Isle	9	HS-ESP	4.69	6.20	0.18	1.09	8.00	6.05
	5	Comanche	2	FF Baghouse	4.03	5.33	0.19	1.03	7.01	5.30
	6	Presque Isle	9	HS-ESP	4.69	6.20	0.18	1.09	8.00	6.05

Scenario 1+4: Best Performing Units as Ranked by Lowest Total Hg Emission (lb/TBtu)
Scenario 2: Best Performing Units as Ranked by Highest Percent Reduction of Mercury Across Control Device(s)
Scenario 3: Best Performing Units as Ranked by Lowest Total Hg Emission (lb/TBtu) and having at least 20% Reduction of Mercury Across Control Device(s)
Scenario 5: Best Performing Units as Ranked by Highest Percent Reduction of Mercury from Coal to Stack
Scenario 6: Best Performing Units as Ranked by Lowest Total Hg Emission (lb/TBtu) and having at least 20% Reduction of Mercury from Coal to Stack
Scenarios 1-3 are based on a combined EMF approach to emission measurement
Scenarios 4-6 are determined from coal mercury content to final emissions
Missing Scenarios result from fewer than 3 plants

Table 4–8. Variability of Ontario-Hydro Method Applied to Annual Average Coal Used at Plant: Calculated from Historical Use

Coal Rank	Scenario No	Plant Name	Unit Number	Technology Control Type	Calculated Hg Emission with Variability due to Coal Switching, lb/TBtu	Corresponding Hg Emission with Variability due to Coal Switching, ug/Nm3	Calculated RSD	Standard Dev. (ug/Nm3)	Calculated 95%CL (ug/Nm3)	Calculated Hg Emission wih Variability due to Coal Switching, including Analytical Variability, lb/TBtu
BITUMINOUS	1	SEI - Birchwood Power Facility	1	SDA/FF	0.28	0.37	0.88	0.33	0.91	0.69
	2	SEI - Birchwood Power Facility	1	SDA/FF	0.28	0.37	0.88	0.33	0.91	0.69
	3	SEI - Birchwood Power Facility	1	SDA/FF	0.28	0.37	0.88	0.33	0.91	0.69
	4	Logan Generating Plant	Gen 1	SDA/FF	0.28	0.37	0.88	0.33	0.90	0.68
	5	Mecklenburg Cogeneration Facility	GEN 1	SDA/FF	0.13	0.17	1.37	0.23	0.56	0.42
	6	Logan Generating Plant	Gen 1	SDA/FF	0.28	0.37	0.88	0.33	0.90	0.68
Lignite	1	Lewis & Clark	B1	PS/Wet FGD Scrubber	8.53	11.29	0.13	1.41	13.61	10.29
	2	Coyote	1	SDA/FF	14.27	18.87	0.09	1.76	21.78	16.46
	4	Lewis & Clark	B1	PS/Wet FGD Scrubber	7.22	9.55	0.14	1.32	11.72	8.86
	5	Antelope Valley Station	B1	SDA/FF	2.17	2.87	0.27	0.79	4.17	3.15
	6	Limestone	LIM1	CS-ESP/Wet FGD Scrubber	15.11	19.99	0.09	1.81	22.96	17.36
Lignite North	1	Lewis & Clark	B1	PS/Wet FGD Scrubber	8.53	11.29	0.13	1.41	13.61	10.29
	2	Antelope Valley Station	B1	SDA/FF	6.11	8.08	0.15	1.23	10.10	7.63
	4	Lewis & Clark	B1	PS/Wet FGD Scrubber	7.22	9.55	0.14	1.32	11.72	8.86
	5	Lewis & Clark	B1	PS/Wet FGD Scrubber	7.22	9.55	0.14	1.32	11.72	8.86
SUBBITUMINOUS	1	Craig	C1	HS-ESP/Wet FGD Scrubber	2.67	3.54	0.24	0.86	4.95	3.74
	2	Wyodak	BW 91	CS-ESP/SDA	11.66	15.42	0.10	1.62	18.08	13.67
	3	Wyodak	BW 91	CS-ESP/SDA	11.66	15.42	0.10	1.62	18.08	13.67
	4	Presque Isle	9	HS-ESP	1.29	1.71	0.37	0.63	2.74	2.07
	5	Comanche	2	FF Baghouse	2.13	2.82	0.28	0.78	4.10	3.10
	6	Presque Isle	9	HS-ESP	1.29	1.71	0.37	0.63	2.74	2.07

Scenario 1+4: Best Performing Units as Ranked by Lowest Total Hg Emission (lb/TBtu)
Scenario 2: Best Performing Units as Ranked by Highest Percent Reduction of Mercury Across Control Device(s)
Scenario 3: Best Performing Units as Ranked by Lowest Total Hg Emission (lb/TBtu) and having at least 20% Reduction of Mercury Across Control Device(s)
Scenario 5: Best Performing Units as Ranked by Highest Percent Reduction of Mercury from Coal to Stack
Scenario 6: Best Performing Units as Ranked by Lowest Total Hg Emission (lb/TBtu) and having at least 20% Reduction of Mercury from Coal to Stack
Scenarios 1-3 are based on a combined EMF approach to emission measurement
Scenarios 4-6 are determined from coal mercury content to final emissions
Missing Scenarios result from fewer than 3 plants

Table 4–9. Summary of the Effects of Measurement Variability

Coal Rank	Scenario No	Plant Name	Unit Number	Technology Control Type	Initial (Test) Hg Emission, lb/TBtu	Calculated Hg Emission (OH Variability), lb/TBtu	Calculated Hg Emission with Variability due to Coal Switching, lb/TBtu	Calculated Hg Emission with Variability due to Coal Switching, including Analytical Variability, lb/TBtu	Calculated Hg Emission with Annual Single Plant Variability due to Coal Switching, lb/TBtu	Calculated Hg Emission wih Annual Single Plant Variability, including Analytical Variability, lb/TBtu
BITUMINOUS	1	SEI - Birchwood Power Facility	1	SDA/FF	0.22	0.58	1.25	2.02	0.28	0.69
	2	SEI - Birchwood Power Facility	1	SDA/FF	0.22	0.58	1.25	2.02	0.28	0.69
	3	SEI - Birchwood Power Facility	1	SDA/FF	0.22	0.58	1.25	2.02	0.28	0.69
	4	Logan Generating Plant	Gen 1	SDA/FF	0.27	0.67	2.56	3.61	0.28	0.68
	5	Mecklenburg Cogeneration Facility	GEN 1	SDA/FF	0.10	0.37	1.27	2.04	0.13	0.42
	6	Logan Generating Plant	Gen 1	SDA/FF	0.27	0.67	2.56	3.61	0.28	0.68
Lignite	1	Lewis & Clark	B1	PS/Wet FGD Scrubber	10.83	12.77	20.31	22.86	8.53	10.29
	2	Coyote	1	SDA/FF	11.72	13.74	24.68	27.45	14.27	16.46
	4	Lewis & Clark	B1	PS/Wet FGD Scrubber	9.16	10.98	17.19	19.57	7.22	8.86
	5	Antelope Valley Station	B1	SDA/FF	2.08	3.04	7.41	9.07	2.17	3.15
	6	Limestone	LIM1	CS-ESP/Wet FGD Scrubber	13.16	15.28	21.53	24.15	15.11	17.36
Lignite North	1	Lewis & Clark	B1	PS/Wet FGD Scrubber	10.83	12.77	11.08	13.05	8.53	10.29
	2	Antelope Valley Station	B1	SDA/FF	5.85	7.34	11.37	13.36	6.11	7.63
	4	Lewis & Clark	B1	PS/Wet FGD Scrubber	9.16	10.98	9.38	11.22	7.22	8.86
	5	Lewis & Clark	B1	PS/Wet FGD Scrubber	9.16	10.98	9.38	11.22	7.22	8.86
SUBBITUMINOUS	1	Craig	C1	HS-ESP/Wet FGD Scrubber	1.58	2.43	10.26	12.17	2.67	3.74
	2	Wyodak	BW 91	CS-ESP/SDA	7.37	9.02	25.45	28.26	11.66	13.67
	3	Wyodak	BW 91	CS-ESP/SDA	7.37	9.02	25.45	28.26	11.66	13.67
	4	Presque Isle	9	HS-ESP	1.26	2.03	4.69	6.05	1.29	2.07
	5	Comanche	2	FF Baghouse	2.66	3.73	4.03	5.30	2.13	3.10
	6	Presque Isle	9	HS-ESP	1.26	2.03	4.69	6.05	1.29	2.07

Scenario 1+4: Best Performing Units as Ranked by Lowest Total Hg Emission (lb/TBtu)
Scenario 2: Best Performing Units as Ranked by Highest Percent Reduction of Mercury Across Control Device(s)
Scenario 3: Best Performing Units as Ranked by Lowest Total Hg Emission (lb/TBtu) and having at least 20% Reduction of Mercury Across Control Device(s)
Scenario 5: Best Performing Units as Ranked by Highest Percent Reduction of Mercury from Coal to Stack
Scenario 6: Best Performing Units as Ranked by Lowest Total Hg Emission (lb/TBtu) and having at least 20% Reduction of Mercury from Coal to Stack
Scenarios 1-3 are based on a combined EMF approach to emission measurement
Scenarios 4-6 are determined from coal mercury content to final emissions
Missing Scenarios result from fewer than 3 plants

5. DISCUSSION OF RESULTS

This report identified many different methods of approaching the development of possible MACT floor values for the control of mercury from coal-fired power plants. These methods include variations in segregating by coal rank, selecting various approaches in determining the best performing units, and the incorporation of analytical uncertainty following the preliminary calculation of MACT floor values.

5.1. General Effects of Various Approaches on MACT

The purpose of presenting these different approaches is not to identify discrete MACT floor values for rulemaking, or even to recommend one set of values over another. Instead, it is to show how MACT floor values are influenced by the selection of approach, and identify some advantages and disadvantages to the approaches considered. These approaches can be further refined in EPA's regulatory development, if desired. For example, this report develops possible MACT floor values as determined from the median of the best performing five units; similar approaches to those described here can be used to develop possible MACT floor values determined from a numerical average of those five units.

5.1.1. Consideration of Subcategories

In developing pollutant emission limits, an initial step is to identify appropriate subcategories. Although this report did comprehensively identify potential subcategories, it made presumptions regarding what subcategories may be reasonable.

This report presumes that there are three subcategories that correspond to the fuel burned: bituminous, subbituminous, and lignite. In addition, only the combustion of these coals in pulverized coal and cyclone boilers were considered. Additional consideration was given to lignite coal origins. Lignite coal originates in the southern United States (e.g. Texas) and northern United States (e.g. North Dakota). As shown in Chapter 4, the mercury content of southern lignite coal is higher than the mercury content of northern lignite coal. Therefore, geographic distinction of northern and southern lignite coal was considered in this report (in addition to the combined lignite category).

In conducting the analyses described in Chapters 3 and 4 of this report, the following advantages and disadvantages were found when attempting to develop subcategories based on coal rank, including the further distinction of northern and southern lignite coals:

- Because of the simplifying assumptions involving fuels burned and the unit types, some of the EPA source data were omitted from the analysis. For example, fuels burned in FBC units or boilers burning a combination of fuels were omitted from virtually all analyses conducted in this report. This initial selection of units is described in Appendix A.

- In reviewing source data, specifically stack-test reports for facilities burning western coals, the tested coal in at least one instance was a "borderline" grade of bituminous/subbituminous. Therefore, slight differences in classification of the source data may result in variations of the computed MACT values.

- Several analyses comparing southern to northern lignite coal could not be completed due to insufficient data. For example, no MACT floor calculation results for southern lignite coal were completed. For northern lignite coal, calculation results were not completed for two of the six scenarios.

5.1.2. *Selection of Approaches*

Chapter 3 summarizes the performance scenarios evaluated. For each of the six scenarios within each of the five coal ranks evaluated, a single facility was selected. The facility selected was the third-best performing unit for the particular scenario. The six scenarios evaluated were as follows:

Scenarios 1–3 are based on a combined EMF approach to emission measurement:

- Scenario 1: Best performing units as ranked by lowest total mercury emission (lb/TBtu).

- Scenario 2: Best performing units as ranked by highest percent reduction of mercury across control device(s).

- Scenario 3: Best performing units as ranked by lowest total mercury emission (lb/TBtu) and having at least 20 percent reduction of mercury across control device(s).

Scenarios 4–6 are determined from coal mercury content to final emissions:

- Scenario 4: Best performing units as ranked by lowest total mercury emission (lb/TBtu).

- Scenario 5: Best performing units as ranked by highest percent reduction of mercury from coal to stack.

- Scenario 6: Best performing units as ranked by lowest total mercury emission (lb/TBtu) and having at least 20 percent reduction of mercury from coal to stack.

Each of these approaches and scenarios results in the calculation of different possible MACT values. As part of selecting the best performing units, the quality of the data contributing to the calculated emission rate or mercury reduction was assessed. This review resulted in the deletion of certain units from the analysis which otherwise may have been part of the set of best performing units for a given scenario, using criteria identified in Chapter 3 of this report. The possible MACT floor values calculated using this approach are equal to or higher than values calculated without using this approach, but the magnitude of this change was not assessed. Incorporation of the data quality assessment led to greater confidence in the values and units selected.

5.1.3. *Incorporation of Variability*

As discussed in Chapter 2 of this report, the MACT floor limitations are not intended to reflect the emission rates measured during tests, but rather the rate of the best performing units "under the most adverse conditions which can reasonably be expected to recur." For this reason, variability was an important part of the analysis, as described in Chapter 4 of this report. This variability is intended to be applied to the "initial" MACT values calculated in Chapter 3 and summarized above. Several different sources of variability were quantified in this report:

- Variability in emission rate resulting from the use of coal with higher mercury or lower chlorine levels than those found during performance testing.

- Variability in emission rate resulting from coal or stack gas analysis.

Each of the coal-switching analyses (changes in mercury or chlorine content) has similar objectives:

- Each accounts for the possibility that the coal mercury or chlorine content may change in the future due to variations at a single source (mine) or variations between sources.

- The magnitude of future variation in mercury and chlorine levels in coal is assumed to be reflected in the ICR-II sampling variation.

- The methods account for long-term variations (such as year-to-year) rather than short-term variations (such as barge-to-barge or train-to-train). Hence these projected variations are appropriate for a MACT floor rate, which uses an annual averaging period. A shorter term compliance averaging period would imply greater variability and a higher MACT floor rate.

- It was assumed that simultaneous selection of both worst chlorine and worst mercury coals would be unlikely and therefore an inappropriate analytical condition.

These sources of variability were combined in various manners, such that the purpose was not to calculate the highest level of variability. Conclusions from the variability analysis include the following:

- For all coals, the impact of coal switching is more dominant than variability in testing. Flue gas testing is a much greater source of uncertainty than coal testing.

- For coal-switching analyses, changes in chlorine coal composition were more significant than changes in mercury coal composition in MACT floor variation for bituminous coal rank units. The converse is true for units burning subbituminous and lignite coals.

- The magnitude of potential changes in emissions as a result of coal switching was expected to reflect the range in coal-switching variability: historical plant average coal variation is expected to be the minimum variation encountered by the plant, while new purchases of worst case coal are expected to be the maximum variation. In all scenarios evaluated, switching to a 95th percentile worst case coal resulted in a higher calculated MACT floor value than the historical plant average coal.

- The reduced efficiency resulting from using a coal with a low chlorine level results in extremely large variability for the bituminous facilities. All third-best facilities evaluated had the same pollution control equipment [spray dryer/fabric filter (SDA/FF)], and therefore the same algorithm was used for evaluation. In developing the algorithms, plants with the same control technology were grouped. In the case of SDA/FF technology, the population consisted of several plants burning relatively high chlorine bituminous coal which resulted in high mercury capture, and several plants burning relatively low chlorine lignite or subbituminous coal which resulted in low mercury capture. The predictive capability of the algorithm for low chlorine bituminous coal is considered less certain than it would be if the data for developing the algorithms had included units burning low chlorine bituminous coal.

- In most cases, algorithms developed based on chlorine and sulfur content did not result in improved correlation as compared to algorithms developed based on chlorine content alone.

There are also differences which result in advantages and disadvantages with each of the coal-switching approaches:

- Simplicity is an advantage to assessing changes in coal mercury level only: the only change in the MACT floor calculation is a new coal mercury level. A disadvantage is that the approach may be unrealistic if mercury coal level is correlated with other properties such as chlorine content that affect collection efficiency.

- Assessing chlorine coal content allowed for consideration of changes in control efficiency. On the other hand, algorithms for some control systems could not be determined because of a low number of data points. In addition, unlike the MACT floor calculations, the algorithms do not distinguish between coal rank. Finally, there was weak correlation in some instances due to scattering of the data.

5.1.4 National Mercury Emission Rates

The following conclusions can be made from results for the different approaches:

- There are fundamental differences to the approaches. In general, Scenarios 2 and 5 will "favor" units with high removal of mercury in the flue gas, while Scenarios 1 and 4 put emphasis on the levels of mercury leaving the stack. Scenarios 3 and 6 combine these two performance criteria, selecting units that emit low levels of mercury through a reduction of mercury in the flue gas, rather than exclusive reliance on low-mercury coal.

- Different definitions of best performing units will result in different units being in the top five and a different third-best unit representing the best performing units. This, in turn, leads to calculation of different MACT floor values.

- The scenario selected for bituminous coal is not critical. For the bituminous coal rank, there is little variation in the performance of the third-best facilities depending on the scenario selected. As shown in Chapter 3, the same five facilities generally appear as the best five facilities regardless of the scenario selected.

- Scenario selection is critical for lignite coal. The same five facilities generally appear as the best five facilities regardless of the scenario, although the large variation in results probably is influenced by the small number of facilities.

- Scenario selection is also critical for subbituminous coal. A facility performing poorly in one scenario can appear as a best five facility in another scenario. For example, Table 3–4 shows that the mercury capture efficiency for the Wyodak facility is 41 percent using Scenario 2, but negative 72 percent using Scenario 5. The Wyodak facility is the third-best performing unit for Scenario 2, but obviously performs poorly in Scenario 5, in which coal measurements are used in conjunction with gas measurements.

- As shown in Appendix D, MACT floor values for Scenario 4 use the control device outlet gas flow rate in the calculation. The EPA source data provide data for the control device inlet flow rate as well (which was not used in the calculations). Examination of these data show that for some units the flow rates differ by only a few percent, while other units have larger differences. In many cases (such as control devices with no bypass), the flow rates are expected to be identical. The fact that they are not equal illustrates some additional measurement variability with regard to flow rate measurement.

- The selection of different scenarios for the MACT standard for subbituminous coal rank has a significant effect on the calculated MACT floor values between each scenario.

The methodology used in extrapolating the possible MACT floor values to national emission rates is detailed in Appendix H. Emission rates are determined for each of the six scenarios involving the three principal coal ranks. (Geographic distinctions between lignite coals were not addressed because of insufficient data for the southern lignite coal category.) National emission estimates were developed for each scenario using two different methods; the intent is that the actual emissions are projected as somewhere within this range:

- As a high end, all coal-fired units were assumed to emit mercury at a rate equal to the MACT floor for the respective coal rank burned.

- As a low end, units that already emit lower than the MACT floor were assumed to continue to emit at this lower level; units emitting higher than the MACT floor will decrease their emissions to the floor value.

Using the source data, the initial (pre-regulatory) mercury emissions is estimated as 50 tons per year. National mercury emission rates were estimated for each of the scenarios with considerations of variability:

- Scenario 1: Range from 12 to 74 tons
- Scenario 2: Range from 24 to 140 tons
- Scenario 3: No estimates due to insufficient data for the lignite subcategory
- Scenario 4: Range from 10 to 58 tons
- Scenario 5: Range from 10 to 40 tons
- Scenario 6: Range from 11 to 61 tons.

In some cases, maximum variations in coal switching leads to an apparent increase in mercury emissions as compared to the pre-regulatory estimate of 50 tons per year, when assuming all plants will emit mercury equal to the MACT standard. However, this is better identified as an upper end, because it is not possible for all plants to use a worst-case coal.

5.2. Comparison to Similar Studies

This section presents and describes previous methodologies used in accounting for variability when using the ICR-III data set to establish possible MACT floor values. Similarities and differences used in these other approaches, as compared to the present report, are described. Emphasis is placed on the approach used rather than the results obtained.

5.2.1. RTI

EPA has evaluated several different methods of accounting for variability in the ICR-III results using these measurement values[11]. This type of analysis principally accounts for measurement uncertainty (sampling and analysis) by using the three stack-test results available for each tested unit. The mean and associated standard deviation for each of the best performing units tested were calculated, and a statistical model was developed to characterize measurement uncertainty. This uncertainty was applied to the average of the best performing units to estimate possible MACT floor values at various confidence limits.

The present report evaluated analysis error associated with the OH method. This is expected to comprise one component of the uncertainty accounted for by RTI.

5.2.2. WEST Associates

WEST Associates prepared a report to present approaches to account for variability and integrate the results with possible MACT floor values. The main method used in accounting for variability was with correlation equations. For each control type (such as cold side ESP) tested, a correlation equation was developed to relate mercury removal to chlorine coal content using data for all tested units in ICR-III. Correlation equations were developed for five control technologies, representing the control technologies

[11] Memorandum, Jeffery Cole (RTI) to William Maxwell (EPA), "Statistical Analysis of Mercury Test Data Variability in Support of a Determination of the MACT Floor for the Regulation of Mercury Air Emissions from Coal-Fired Electric Utility Plants," August 28, 2002.

used by the best performing units within each coal rank (bituminous, subbituminous, lignite), using chlorine content as the independent variable.

The developed algorithms were used in conjunction with the ICR-II sampling data to calculate possible mercury emissions over time for the best performing units, and the 95th percentile of the distribution for each best performing unit was determined. Based on these five values, the mean and 95th percentile upper confidence limit of the mean was calculated for each coal rank.

There are similarities and differences between the WEST report and this report:

- Both present possible MACT floors as a function of coal rank. The present report develops possible MACT values for geographic distinctions of lignite. The WEST report develops possible MACT values for the combined lignite only.

- Both account for variability in fuel; the ICR-III and ICR-II data sets together were used in assessing this variability.

- As part of the calculation procedure, both reports exclude from analyses ICR-III data from 15 of the 80 units tested.

- Each report develops algorithms based on control device using the ICR-III data, and applies the algorithms to the best performing units as a way of estimating variability. The algorithms relate mercury removal to chlorine coal content. The present report also identifies variability associated with sulfur (in addition to chlorine) for the cold side ESP control technology.

- The WEST Associates approach applies the algorithms to individual data points (from the ICR-II measurements), whereas the present study applies results to annual average values.

5.2.3. The Utility Air Regulatory Group and EPRI

The Utility Air Regulatory Group (UARG) conducted a variability analysis using the ICR data.[12] The variability analysis used regression equations developed by EPRI in 2000 for 10 control technology classes based on EPA's stack-test data. For each control technology class, two regression equations were developed: one to predict mercury removal efficiency and a second to predict the percentage of elemental mercury in the emitted stack gas. All but 1 of the technology classes (9 of 10) use coal chlorine content (as ln Cl) as the independent variable; a coal chlorine-to-sulfur ratio was used as the independent variable for the cold-side ESP technology class.

The UARG analysis applied the algorithms to the units represented in the ICR-II sampling program. Mercury removal and mercury emissions were estimated from each sample represented, using the sampled coal's chlorine and mercury properties. The resultant data (such as pounds mercury emitted per Btu) was graphed as a distribution of cumulative frequency. The graphs illustrate the expected variation in control/emissions with variations in coal properties.

Similarly, the present study developed algorithms using the ICR-III data, and found that ln (Cl) was a satisfactory independent variable for most control devices and that the Cl-S ratio gave an improved correlation for the cold-side ESP technology class. The UARG approach applies the algorithms to individual data points (from the ICR-II measurements) whereas the present study applies results to annual average values.

[12] Memorandum. From Ralph Roberson, RMB Consulting, to Bob Wayland, Regarding UARG Variability Analysis. September 4, 2002.

Appendix A. Facilities with Relevant Emissions Data

Mercury emission data were obtained from the following three sources:

- EPA's report, Control of Mercury Emissions from Coal-fired Electric Utility Boilers: Interim Report Including Errata Dated 3-21-02 (OAQPS/USEPA, EPA-600/R-01-109, April 2002).

- EPA's Electric Utility Steam Generating Units Section 112 Rulemaking Website, http://www.epa.gov/ttn/atw/combust/utiltox/rawdata1.xls.

- EPA's website, http://www.epa.gov/ttn/atw/combust/utiltox/control2.zip(bintable.xls).

These sources included results from 81 boiler and coal-type configurations obtained from the ICR-III testing. Not all of these data were used in this report. The purpose of excluding certain data is to provide consistency in the results. Specifically, the following types of facilities/ units were omitted:

- Integrated Gasification Combined Cycle (IGCC) and fluidized bed combustion (FBC) units. Each of these unit types process coal in a different manner than other units (cyclone and pulverized coal technologies) representing the vast majority of boilers.

- Units burning unusual fuels, specifically waste coal materials or petroleum coke. Facilities burning anthracite waste coal, bituminous waste coal, or petroleum coke (as the sole fuels or in combination with other coal fuels) were excluded from the analysis. These units were excluded because they use fuels different from the vast majority of units (bituminous, subbituminous, lignite).

- Units burning blends of bituminous, subbituminous, and/or lignite coals. In this report, possible MACT floors are differentiated on the basis of coal type. Therefore, a unit burning a blend of bituminous and subbituminous coals cannot be easily classified into one of these discrete categories.

Chapter 3 of this report identifies the facilities specifically included and excluded as a result of applying these guidelines.

Appendix B. Data Integrity Issues with Candidate MACT Floor Facilities

Data integrity issues were investigated in detail for the facilities with a ranking in the top five of the preliminary MACT floor analysis. These facilities were investigated in detail to determine if there are any reasons that would preclude the use of the data for calculations. The purpose of this step is to exclude flawed data from the analysis as well as to flag potential data abnormalities.

For efficiency, this evaluation was only conducted on the subset of units that would likely contribute to a MACT floor calculation, rather than conducting this analysis for all 80 contributing units. In some cases, statistical and data summary calculations were conducted for all 80 contributing units, due to the ease of computer calculations. However, subsequent evaluations of these data, as well as investigation of more qualitative results, were only conducted for the subset of units described above.

Data evaluation issues were identified based on the potential impact of data abnormality, and the availability of data to assess the potential abnormality for each of the units. These issues are identified in Table B–1. For an ideal case, all questions would be answered 'Yes' for a given unit's data. For each issue receiving a negative response, the significance of the potential abnormality is listed with a factor of 1 to 4 (with 4 representing the most severe reservations). Following evaluation of all issues for a given unit's data, the unit's overall factor is set equal to the most restrictive quality ranking for any one issue. A unit with an overall factor of 1 or 2 would be determined to be acceptable for use in analysis, while a unit with an overall factor of 3 or 4 would be excluded from the data analysis.

Table B–1. Information Items to Assess Data Integrity

Flag ID	Subject Area	Assessment Question	Weight for Negative Response	Discussion
1	Consistency between ICR-II and ICR-III mercury and chlorine coal values	Are the stack test results for mercury in the feed coal statistically similar to the ICR-II results?	**3**	Dissimilar values for mercury or chlorine in coal are indicative of at least one of the following undesirable situations: (1) the ICR-III results are not representative of typical prior year conditions, or (2) there were sampling and analysis errors for the ICR-III coal measurements. Errors of this type are more significant for mercury than for other parameters such as chlorine.
2		Are the stack test results for chlorine in the feed coal statistically similar to the ICR-II results?	1.1	
3	Negative percent reduction across control or from coal to stack	Is there positive percent reduction (i.e., mercury removal) across both the measured control device and from coal to stack?	**3**	The mass flow rate of mercury should be highest in the coal inlet, an intermediate value at the final control inlet, and lowest in the stack. However, sampling and analysis methods introduce variability in these measurements, particularly due to the use of different methods for solid (coal) and gaseous matrices. For this reason the mass flow rates or concentrations may not follow the above linear progression through the system. While such a situation is not ideal, the data quality is most suspect if the stack measurement results in the highest concentration or mass flow rate, which subsequently results in a negative percent reduction throughout the system (as determined between both the coal and the control).
4		Is there positive percent reduction across either the measured control device or from coal to stack?	2	
5	Consistency of mercury mass flow	Does the calculated mercury mass flow have the appropriate trend across the system (i.e., highest in feed and lowest in stack)?	2	

Flag ID	Subject Area	Assessment Question	Weight for Negative Response	Discussion
6	Non-detects in coal feed	Is there at least one detected value in the ICR-III mercury coal measurements?	**3**	Non-detect mercury levels in coal signify very low mercury values throughout the system, contributing to low stack releases and potential difficulty in estimating control efficiency. In addition, there is much uncertainty with a non-detect value.
7	Non-detects in gas	Is mercury detected in at least one control inlet sample?	2	An inconsistent result occurs if mercury is not detected in the control inlet but detected in the stack outlet. There is much uncertainty with a non-detect value, so it is possible that mercury is present but below detection limits.
8	Precision of stack test results	Do the three stack test results (control inlet and stack) exhibit acceptable variation?	2	Extremely high variation in the test results implies difficulties in obtaining reproducible data.
9	Problems during sampling or analysis, as documented in the stack test report?	Do the recommendations within the report body advise that all tests were conducted in a satisfactory manner?	**4**	Individual tests with obvious problems should be excluded from analyses. Typically this will result in a single run being excluded, with the remaining two runs valid.
10		Are there three, rather than only two, valid test runs?	1.1	While it is preferred to have three rather than two data points for calculations, this factor alone is not expected to significantly affect data quality.
11		Are all Ontario-Hydro speciation results valid, and if not is a particular result likely to have a significant affect on the results?	**3**	In some cases, the concentration of all three mercury species in the control inlet and/or outlet could not be determined; contributions are assumed to be zero in these cases. To the extent possible, the reasonableness of this assumption is evaluated based on other available data.
12	Normal operating conditions of system, as documented in the stack test report?	Based on information presented in the stack test report, does the APC system and boiler appear to be in normal operation during the stack test?	2	To the extent that operational information is available, the conditions during the test runs should be within the range of self-described normal operating conditions. However, because the reports do not provide much detail in this regard, it is most practical to only indicate that this situation is present.
13	Other Issues	Are there any other issues that may affect the quality of the results?	Varies; 1.1 to 3	Accounts for any miscellaneous issues not identified above.

Flags:
1 – Good. Little or no reservations with data
2 – Satisfactory. Some reservations with data
3 – Poor. Inconsistencies with data
4 – Severe. Documented problems during testing or severe inconsistencies with data

The most critical flags are those with values of 3 or 4, thereby precluding their use in analysis. The results of the best performing units for each of the six scenarios described in Chapter 3 are listed in Tables B–2 to B–7. Table B–8 lists the units identified as one of the top 5 in any of the six MACT floor scenarios and five coal classifications. Of the 29 units identified as a "Top 5" unit in this table, 11 of these units had flag values of 3 or 4. The specific problems associated with these eleven units are identified below:

- Dwayne Collier Battle Cogeneration (Unit 2B; bituminous). Mercury was non-detected in test coal in all three runs (Flag 6). In addition, the mercury concentration in the test coal was inconsistent with the values measured in ICR-II in all three runs (Flag 1).

- Valmont (Unit 5; bituminous). The mercury concentration in the test coal was lower than the values measured in ICR-II in all three runs (Flag 1).

- Leland Olds Station (Unit 2; lignite north). There was negative mercury removal in Run 1 (Flag 3). For this unit, only results from two valid runs are available in the EPA data.

- Bay Front Plant Generating (Unit 5; lignite north). There was negative mercury removal in Runs 2 and 3 (Flag 3). The test report for Bay Front identifies that the facility burns bituminous coal, while the unit is classified in the EPA data analysis as lignite. In addition, the report identifies that the control system consists of a multiclone followed by a mechanical collector, with only the mechanical collector sampled. However, the presence of the multiclone is not otherwise identified in the data sheets (Flag 13).

- Stanton Station (Unit 10; lignite north). There was negative mercury removal in Run 3 (Flag 3).

- Monticello (Unit 3; lignite south) The mercury concentration in the test coal is inconsistent with the results of ICR-II for Run 3 (Flag 1).

- Monticello (Unit 1; lignite south). Negative removal in Runs 2 and 3 (Flag 3); inconsistent mercury in test coal versus ICR-II for Run 3 (Flag 1).

- Craig (Unit C3; subbitumnous). Inconsistent mercury in test coal versus ICR-II all runs (Flag 1).

- Laramie River Station (Unit 3; subbitumnous). Inconsistent mercury in test coal versus ICR-II all runs (Flag 1).

- Laramie River Station (Unit 1; subbitumnous). Inconsistent mercury in test coal versus ICR-II all runs (Flag 1).

- Montrose (Unit 1; subbituminous). Inconsistent mercury in test coal versus ICR-II all runs (Flag 1).

Removing these 11 facilities from the analysis results in a significant re-ordering of the best performing units. The revised results are given in Table B–9, and are obtained directly from Table B–8.

Table B–2. Parameters for Best Performing Units Based on Lowest Total Hg Emission (OH) (Scenario 1)

Coal Rank	Plant ID	Unit Number	Technology Control Type	Average Sampled Coal at Plant, lb Hg/TBtu	Average Sampled Coal at Plant, lb Cl/TBtu	Annual Average Coal at Plant, lb Hg/TBtu	Scenario 1: Average Outlet Emission, lb Hg/TBtu	Scenario 4: Average Outlet Emission, lb Hg/TBtu	Scenario 5: Average % Hg Reduction Coal to Stack	Average % Hg Reduction Across Last Control Device	EPA Average EMF for Last Control Device	EPA Average EMF for First Control Device	Scenario Average % Reductio Across A Control Device(s
BITUMINOUS	Dwayne Collier Battle Cogeneration	2B	SDA/FF	2.1609	122417	5.542	0.0980	0.104	95.95	94.25	0.063		94.25
	Valmont	5	FF Baghouse	0.6591	3192	3.092	0.1243	0.148	71.16	86.89	0.135		86.89
	Mecklenburg Cogeneration Facility	GEN	SDA/FF	6.9421	135886	6.917	0.1697	0.103	98.07	97.91	0.012		97.91
	Logan Generating Plant	Gen	SCR/SDA/FF	13.0807	109006	13.348	0.1913	0.273	98.51	98.53	0.025		98.53
	SEI - Birchwood Power Facility	1	SCR/SDA/FF	8.7630	73100	11.280	0.2176	0.244	97.45	97.56	0.026		97.56
Lignite	Bay Front Plant Generating	5	Mechanical Collector	4.7343	10028	2.126	3.5694	6.987	-51.99	-57.07	1.571		-57.07
	Leland Olds Station	2	CS-ESP	3.8073	9193	6.718	4.0201	4.051	25.65	7.29	0.951		7.29
	Antelope Valley Station	B1	SDA/FF	6.0297	10417	6.302	5.8454	2.079	42.73	1.11	0.667		1.11
	Stanton Station	10	SDA/FF	7.9315	2690	8.301	7.6863	8.144	11.39	-1.02	0.985		-1.02
	Stanton Station	1	CS-ESP	7.6858	4701	8.301	8.6522	2.423	57.12	-3.57	1.035		-3.56
Lignite North	Bay Front Plant Generating	5	Mechanical Collector	4.7343	10028	2.126	3.5694	6.987	-51.99	-57.07	1.571		-57.07
	Leland Olds Station	2	CS-ESP	3.8073	9193	6.718	4.0201	4.051	25.65	7.29	0.951		7.29
	Antelope Valley Station	B1	SDA/FF	6.0297	10417	6.302	5.8454	2.079	42.73	1.11	0.667		1.11
	Stanton Station	10	SDA/FF	7.9315	2690	8.301	7.6863	8.144	11.39	-1.02	0.985		-1.02
	Stanton Station	1	CS-ESP	7.6858	4701	8.301	8.6522	2.423	57.12	-3.57	1.035		-3.56
Lignite South	Limestone	LIM	CS-ESP/Wet FGD Scrubber	13.1376	4733	15.086	13.6298	13.162	51.02	51.02	0.490	1.035	49.33
	Monticello	3	CS-ESP/Wet FGD Scrubber	48.4346	15735	15.605	22.2318	20.550	36.44	36.44	0.636	1.035	34.24
	Big Brown	1	CS-ESP/FF (COHPAC)	32.6654	15025	13.684	30.0162	29.391	14.96	-7.68	1.081	1.035	-11.79
	Monticello	1	CS-ESP/FF (COHPAC)	46.2123	20720	15.605	55.5497	56.035	-19.83	-21.20	1.213	1.035	-25.40
SUBBITUMINOUS	Craig	C3	SDA/FF	0.7951	9284	2.082	0.6527	0.690	13.58	35.76	0.664		35.76
	Clay Boswell	2	FF Baghouse	4.6742	4127	5.769	0.6599	0.686	85.10	82.61	0.174		82.61
	Cholla	3	HS-ESP	3.0434	4148	5.463	1.2169	1.076	96.46	2.28	1.363		2.28
	Craig	C1	HS-ESP/Wet FGD Scrubber	1.8269	21531	2.082	1.5779	1.527	31.06	22.81	0.777	1.077	16.85
	Coronado	U1B	HS-ESP/Wet FGD Scrubber	3.0969	10356	4.951	2.1302	2.228	11.46	0.86	1.152	1.077	-6.80

Table B–3. Parameters for Best Performing Units Based on Highest Percent Reduction of Mercury Across Control Device(s) (Scenario 2)

Coal Rank	Plant ID	Unit Number	Technology Control Type	Average Sampled Coal at Plant, lb Hg/TBtu	Average Sampled Coal at Plant, lb Cl/TBtu	Annual Average Coal at Plant, lb Hg/TBtu	Scenario 1: Average Outlet Emission, lb Hg/TBtu	Scenario 4: Average Outlet Emission, lb Hg/TBtu	Scenario 5: Average % Hg Reduction Coal to Stack	Average % Hg Reduction Across Last Control Device	EPA Average EMF for Last Control Device	EPA Average EMF for First Control Device	Scenario Average % Reductio Across A Control Device(s
BITUMINOUS	Logan Generating Plant	Gen	SCR/SDA/FF	13.0807	109006	13.348	0.1913	0.273	98.51	98.53	0.025		98.53
	Mecklenburg Cogeneration Facility	GEN	SDA/FF	6.9421	135886	6.917	0.1697	0.103	98.07	97.91	0.012		97.91
	SEI - Birchwood Power Facility	1	SCR/SDA/FF	8.7630	73100	11.280	0.2176	0.244	97.45	97.56	0.026		97.56
	Clover Power Station	2	FF/Wet FGD Scrubber	12.1344	38659	7.241	0.3969	0.339	98.13	76.43	0.237	0.106	97.50
	Intermountain	2SG	FF/Wet FGD Scrubber	1.7976	15394	2.962	0.3180	0.285	97.48	68.16	0.255	0.106	96.62
Lignite	Limestone	LIM	CS-ESP/Wet FGD Scrubber	13.1376	4733	15.086	13.6298	13.162	51.02	51.02	0.490	1.035	49.33
	Monticello	3	CS-ESP/Wet FGD Scrubber	48.4346	15735	15.605	22.2318	20.550	36.44	36.44	0.636	1.035	34.24
	Lewis & Clark	B1	PS/Wet FGD Scrubber	11.4561	9599	9.030	10.8254	9.164	8.78	32.77	0.672		32.77
	Coyote	1	SDA/FF	10.2057	9189	12.427	11.7196	18.408	-48.67	8.64	0.618		8.65
	Leland Olds Station	2	CS-ESP	3.8073	9193	6.718	4.0201	4.051	25.65	7.29	0.951		7.29
Lignite North	Lewis & Clark	B1	PS/Wet FGD Scrubber	11.4561	9599	9.030	10.8254	9.164	8.78	32.77	0.672		32.77
	Coyote	1	SDA/FF	10.2057	9189	12.427	11.7196	18.408	-48.67	8.64	0.618		8.65
	Leland Olds Station	2	CS-ESP	3.8073	9193	6.718	4.0201	4.051	25.65	7.29	0.951		7.29
	Antelope Valley Station	B1	SDA/FF	6.0297	10417	6.302	5.8454	2.079	42.73	1.11	0.667		1.11
	Stanton Station	10	SDA/FF	7.9315	2690	8.301	7.6863	8.144	11.39	-1.02	0.985		-1.02
Lignite South	Limestone	LIM	CS-ESP/Wet FGD Scrubber	13.1376	4733	15.086	13.6298	13.162	51.02	51.02	0.490	1.035	49.33
	Monticello	3	CS-ESP/Wet FGD Scrubber	48.4346	15735	15.605	22.2318	20.550	36.44	36.44	0.636	1.035	34.24
	Big Brown	1	CS-ESP/FF (COHPAC)	32.6654	15025	13.684	30.0162	29.391	14.96	-7.68	1.081	1.035	-11.79
	Monticello	1	CS-ESP/FF (COHPAC)	46.2123	20720	15.605	55.5497	56.035	-19.83	-21.20	1.213	1.035	-25.40
SUBBITUMINOUS	Clay Boswell	2	FF Baghouse	4.6742	4127	5.769	0.6599	0.686	85.10	82.61	0.174		82.61
	Comanche	2	FF Baghouse	7.8487	4205	6.291	2.8139	2.661	75.14	62.26	0.374		62.26
	Laramie River Station	1	CS-ESP/Wet FGD Scrubber	10.0307	6221	4.392	3.7177	3.236	53.86	51.55	0.484	0.974	52.83
	Wyodak	BW	CS-ESP/SDA	3.4395	2151	5.444	7.3684	8.067	-71.65	41.27	0.566		41.27
	Laramie River Station	3	CS-ESP/SDA	10.4237	6442	4.392	3.3304	3.050	70.56	39.96	1.785		39.96

Table B–4. Parameters for Best Performing Units Based on Lowest Total Hg Emission and 20% Reduction (Scenario 3)

Coal Rank	Plant ID	Unit Number	Technology Control Type	Average Sampled Coal at Plant, lb Hg/TBtu	Average Sampled Coal at Plant, lb Cl/TBtu	Annual Average Coal at Plant, lb Hg/TBtu	Scenario 1: Average Outlet Emission, lb Hg/TBtu	Scenario 4: Average Outlet Emission, lb Hg/TBtu	Scenario 5: Average % Hg Reduction Coal to Stack	Average % Hg Reduction Across Last Control Device	EPA Average EMF for Last Control Device	EPA Average EMF for First Control Device	Scenario Average % Reductio Across A Control Device(s
BITUMINOUS	Dwayne Collier Battle Cogeneration	2B	SDA/FF	2.1609	122417	5.542	0.0980	0.104	95.95	94.25	0.063		94.25
	Valmont	5	FF Baghouse	0.6591	3192	3.092	0.1243	0.148	71.16	86.89	0.135		86.89
	Mecklenburg Cogeneration Facility	GEN	SDA/FF	6.9421	135886	6.917	0.1697	0.103	98.07	97.91	0.012		97.91
	Logan Generating Plant	Gen	SCR/SDA/FF	13.0807	109006	13.348	0.1913	0.273	98.51	98.53	0.025		98.53
	SEI - Birchwood Power Facility	1	SCR/SDA/FF	8.7630	73100	11.280	0.2176	0.244	97.45	97.56	0.026		97.56
Lignite	Lewis & Clark	B1	PS/Wet FGD Scrubber	11.4561	9599	9.030	10.8254	9.164	8.78	32.77	0.672		32.77
	Limestone	LIM	CS-ESP/Wet FGD Scrubber	13.1376	4733	15.086	13.6298	13.162	51.02	51.02	0.490	1.035	49.33
	Monticello	3	CS-ESP/Wet FGD Scrubber	48.4346	15735	15.605	22.2318	20.550	36.44	36.44	0.636	1.035	34.24
Lignite North	Lewis & Clark	B1	PS/Wet FGD Scrubber	11.4561	9599	9.030	10.8254	9.164	8.78	32.77	0.672		32.77
Lignite South	Limestone	LIM	CS-ESP/Wet FGD Scrubber	13.1376	4733	15.086	13.6298	13.162	51.02	51.02	0.490	1.035	49.33
	Monticello	3	CS-ESP/Wet FGD Scrubber	48.4346	15735	15.605	22.2318	20.550	36.44	36.44	0.636	1.035	34.24
SUBBITUMINOUS	Craig	C3	SDA/FF	0.7951	9284	2.082	0.6527	0.690	13.58	35.76	0.664		35.76
	Clay Boswell	2	FF Baghouse	4.6742	4127	5.769	0.6599	0.686	85.10	82.61	0.174		82.61
	Comanche	2	FF Baghouse	7.8487	4205	6.291	2.8139	2.661	75.14	62.26	0.374		62.26
	Laramie River Station	3	CS-ESP/SDA	10.4237	6442	4.392	3.3304	3.050	70.56	39.96	1.785		39.96
	Laramie River Station	1	CS-ESP/Wet FGD Scrubber	10.0307	6221	4.392	3.7177	3.236	53.86	51.55	0.484	0.974	52.83

Table B–5. Parameters for Best Performing Units Based on Lowest Hg Emission (Coal) (Scenario 4)

Coal Rank	Plant ID	Unit Number	Technology Control Type	Average Sampled Coal at Plant, lb Hg/TBtu	Average Sampled Coal at Plant, lb Cl/TBtu	Annual Average Coal at Plant, lb Hg/TBtu	Scenario 1: Average Outlet Emission, lb Hg/TBtu	Scenario 4: Average Outlet Emission, lb Hg/TBtu	Scenario 5: Average % Hg Reduction Coal to Stack	Average % Hg Reduction Across Last Control Device	EPA Average EMF for Last Control Device	EPA Average EMF for First Control Device	Scenario Average % Reductio Across A Control Device(s
BITUMINOUS	Mecklenburg Cogeneration Facility	GEN	SDA/FF	6.9421	135886	6.917	0.1697	0.103	98.07	97.91	0.012		97.91
	Dwayne Collier Battle Cogeneration	2B	SDA/FF	2.1609	122417	5.542	0.0980	0.104	95.95	94.25	0.063		94.25
	Valmont	5	FF Baghouse	0.6591	3192	3.092	0.1243	0.148	71.16	86.89	0.135		86.89
	SEI - Birchwood Power Facility	1	SCR/SDA/FF	8.7630	73100	11.280	0.2176	0.244	97.45	97.56	0.026		97.56
	Logan Generating Plant	Gen	SCR/SDA/FF	13.0807	109006	13.348	0.1913	0.273	98.51	98.53	0.025		98.53
Lignite	Antelope Valley Station	B1	SDA/FF	6.0297	10417	6.302	5.8454	2.079	42.73	1.11	0.667		1.11
	Stanton Station	1	CS-ESP	7.6858	4701	8.301	8.6522	2.423	57.12	-3.57	1.035		-3.56
	Leland Olds Station	2	CS-ESP	3.8073	9193	6.718	4.0201	4.051	25.65	7.29	0.951		7.29
	Bay Front Plant Generating	5	Mechanical Collector	4.7343	10028	2.126	3.5694	6.987	-51.99	-57.07	1.571		-57.07
	Stanton Station	10	SDA/FF	7.9315	2690	8.301	7.6863	8.144	11.39	-1.02	0.985		-1.02
Lignite North	Antelope Valley Station	B1	SDA/FF	6.0297	10417	6.302	5.8454	2.079	42.73	1.11	0.667		1.11
	Stanton Station	1	CS-ESP	7.6858	4701	8.301	8.6522	2.423	57.12	-3.57	1.035		-3.56
	Leland Olds Station	2	CS-ESP	3.8073	9193	6.718	4.0201	4.051	25.65	7.29	0.951		7.29
	Bay Front Plant Generating	5	Mechanical Collector	4.7343	10028	2.126	3.5694	6.987	-51.99	-57.07	1.571		-57.07
	Stanton Station	10	SDA/FF	7.9315	2690	8.301	7.6863	8.144	11.39	-1.02	0.985		-1.02
Lignite South	Limestone	LIM	CS-ESP/Wet FGD Scrubber	13.1376	4733	15.086	13.6298	13.162	51.02	51.02	0.490	1.035	49.33
	Monticello	3	CS-ESP/Wet FGD Scrubber	48.4346	15735	15.605	22.2318	20.550	36.44	36.44	0.636	1.035	34.24
	Big Brown	1	CS-ESP/FF (COHPAC)	32.6654	15025	13.684	30.0162	29.391	14.96	-7.68	1.081	1.035	-11.79
	Monticello	1	CS-ESP/FF (COHPAC)	46.2123	20720	15.605	55.5497	56.035	-19.83	-21.20	1.213	1.035	-25.40
SUBBITUMINOUS	Clay Boswell	2	FF Baghouse	4.6742	4127	5.769	0.6599	0.686	85.10	82.61	0.174		82.61
	Craig	C3	SDA/FF	0.7951	9284	2.082	0.6527	0.690	13.58	35.76	0.664		35.76
	Cholla	3	HS-ESP	3.0434	4148	5.463	1.2169	1.076	96.46	2.28	1.363		2.28
	Presque Isle	9	HS-ESP	3.1866	15750	3.235	5.0708	1.258	25.73	-3.63	1.036		-3.63
	Craig	C1	HS-ESP/Wet FGD Scrubber	1.8269	21531	2.082	1.5779	1.527	31.06	22.81	0.777	1.077	16.85

Table B–6. Parameters for Best Performing Units Based on Greatest Percent Reduction (Coal) (Scenario 5)

Coal Rank	Plant ID	Unit Number	Technology Control Type	Average Sampled Coal at Plant, lb Hg/TBtu	Average Sampled Coal at Plant, lb Cl/TBtu	Annual Average Coal at Plant, lb Hg/TBtu	Scenario 1: Average Outlet Emission, lb Hg/TBtu	Scenario 4: Average Outlet Emission, lb Hg/TBtu	Scenario 5: Average % Hg Reduction Coal to Stack	Average % Hg Reduction Across Last Control Device	EPA Average EMF for Last Control Device	EPA Average EMF for First Control Device	Scenario Average % Reductio Across A Control Device(s
BITUMINOUS	Logan Generating Plant	Gen	SCR/SDA/FF	13.0807	109006	13.348	0.1913	0.273	98.51	98.53	0.025		98.53
	Clover Power Station	2	FF/Wet FGD Scrubber	12.1344	38659	7.241	0.3969	0.339	98.13	76.43	0.237	0.106	97.50
	Mecklenburg Cogeneration Facility	GEN	SDA/FF	6.9421	135886	6.917	0.1697	0.103	98.07	97.91	0.012		97.91
	Intermountain	2SG	FF/Wet FGD Scrubber	1.7976	15394	2.962	0.3180	0.285	97.48	68.16	0.255	0.106	96.62
	SEI - Birchwood Power Facility	1	SCR/SDA/FF	8.7630	73100	11.280	0.2176	0.244	97.45	97.56	0.026		97.56
Lignite	Stanton Station	1	CS-ESP	7.6858	4701	8.301	8.6522	2.423	57.12	-3.57	1.035		-3.56
	Limestone	LIM	CS-ESP/Wet FGD Scrubber	13.1376	4733	15.086	13.6298	13.162	51.02	51.02	0.490	1.035	49.33
	Antelope Valley Station	B1	SDA/FF	6.0297	10417	6.302	5.8454	2.079	42.73	1.11	0.667		1.11
	Monticello	3	CS-ESP/Wet FGD Scrubber	48.4346	15735	15.605	22.2318	20.550	36.44	36.44	0.636	1.035	34.24
	Leland Olds Station	2	CS-ESP	3.8073	9193	6.718	4.0201	4.051	25.65	7.29	0.951		7.29
Lignite North	Stanton Station	1	CS-ESP	7.6858	4701	8.301	8.6522	2.423	57.12	-3.57	1.035		-3.56
	Antelope Valley Station	B1	SDA/FF	6.0297	10417	6.302	5.8454	2.079	42.73	1.11	0.667		1.11
	Leland Olds Station	2	CS-ESP	3.8073	9193	6.718	4.0201	4.051	25.65	7.29	0.951		7.29
	Stanton Station	10	SDA/FF	7.9315	2690	8.301	7.6863	8.144	11.39	-1.02	0.985		-1.02
	Lewis & Clark	B1	PS/Wet FGD Scrubber	11.4561	9599	9.030	10.8254	9.164	8.78	32.77	0.672		32.77
Lignite South	Limestone	LIM	CS-ESP/Wet FGD Scrubber	13.1376	4733	15.086	13.6298	13.162	51.02	51.02	0.490	1.035	49.33
	Monticello	3	CS-ESP/Wet FGD Scrubber	48.4346	15735	15.605	22.2318	20.550	36.44	36.44	0.636	1.035	34.24
	Big Brown	1	CS-ESP/FF (COHPAC)	32.6654	15025	13.684	30.0162	29.391	14.96	-7.68	1.081	1.035	-11.79
	Monticello	1	CS-ESP/FF (COHPAC)	46.2123	20720	15.605	55.5497	56.035	-19.83	-21.20	1.213	1.035	-25.40
SUBBITUMINOUS	Cholla	3	HS-ESP	3.0434	4148	5.463	1.2169	1.076	96.46	2.28	1.363		2.28
	Clay Boswell	2	FF Baghouse	4.6742	4127	5.769	0.6599	0.686	85.10	82.61	0.174		82.61
	Montrose	1	CS-ESP	9.5743	12797	3.484	5.8933	6.137	82.92	9.23	0.907		9.23
	Comanche	2	FF Baghouse	7.8487	4205	6.291	2.8139	2.661	75.14	62.26	0.374		62.26
	Laramie River Station	3	CS-ESP/SDA	10.4237	6442	4.392	3.3304	3.050	70.56	39.96	1.785		39.96

Table B–7. Parameters for Best Performing Units Based on Lowest Total Hg Emission and 20% Reduction (Scenario 6)

Coal Rank	Plant ID	Unit Number	Technology Control Type	Average Sampled Coal at Plant, lb Hg/TBtu	Average Sampled Coal at Plant, lb Cl/TBtu	Annual Average Coal at Plant, lb Hg/TBtu	Scenario 1: Average Outlet Emission, lb Hg/TBtu	Scenario 4: Average Outlet Emission, lb Hg/TBtu	Scenario 5: Average % Hg Reduction Coal to Stack	Average % Hg Reduction Across Last Control Device	EPA Average EMF for Last Control Device	EPA Average EMF for First Control Device	Scenario Average % Reductio Across A Control Device(s
BITUMINOUS	Mecklenburg Cogeneration Facility	GEN	SDA/FF	6.9421	135886	6.917	0.1697	0.103	98.07	97.91	0.012		97.91
	Dwayne Collier Battle Cogeneration	2B	SDA/FF	2.1609	122417	5.542	0.0980	0.104	95.95	94.25	0.063		94.25
	Valmont	5	FF Baghouse	0.6591	3192	3.092	0.1243	0.148	71.16	86.89	0.135		86.89
	SEI - Birchwood Power Facility	1	SCR/SDA/FF	8.7630	73100	11.280	0.2176	0.244	97.45	97.56	0.026		97.56
	Logan Generating Plant	Gen	SCR/SDA/FF	13.0807	109006	13.348	0.1913	0.273	98.51	98.53	0.025		98.53
Lignite	Antelope Valley Station	B1	SDA/FF	6.0297	10417	6.302	5.8454	2.079	42.73	1.11	0.667		1.11
	Stanton Station	1	CS-ESP	7.6858	4701	8.301	8.6522	2.423	57.12	-3.57	1.035		-3.56
	Leland Olds Station	2	CS-ESP	3.8073	9193	6.718	4.0201	4.051	25.65	7.29	0.951		7.29
	Limestone	LIM	CS-ESP/Wet FGD Scrubber	13.1376	4733	15.086	13.6298	13.162	51.02	51.02	0.490	1.035	49.33
	Monticello	3	CS-ESP/Wet FGD Scrubber	48.4346	15735	15.605	22.2318	20.550	36.44	36.44	0.636	1.035	34.24
Lignite North	Antelope Valley Station	B1	SDA/FF	6.0297	10417	6.302	5.8454	2.079	42.73	1.11	0.667		1.11
	Stanton Station	1	CS-ESP	7.6858	4701	8.301	8.6522	2.423	57.12	-3.57	1.035		-3.56
	Leland Olds Station	2	CS-ESP	3.8073	9193	6.718	4.0201	4.051	25.65	7.29	0.951		7.29
Lignite South	Limestone	LIM	CS-ESP/Wet FGD Scrubber	13.1376	4733	15.086	13.6298	13.162	51.02	51.02	0.490	1.035	49.33
	Monticello	3	CS-ESP/Wet FGD Scrubber	48.4346	15735	15.605	22.2318	20.550	36.44	36.44	0.636	1.035	34.24
SUBBITUMINOUS	Clay Boswell	2	FF Baghouse	4.6742	4127	5.769	0.6599	0.686	85.10	82.61	0.174		82.61
	Cholla	3	HS-ESP	3.0434	4148	5.463	1.2169	1.076	96.46	2.28	1.363		2.28
	Presque Isle	9	HS-ESP	3.1866	15750	3.235	5.0708	1.258	25.73	-3.63	1.036		-3.63
	Craig	C1	HS-ESP/Wet FGD Scrubber	1.8269	21531	2.082	1.5779	1.527	31.06	22.81	0.777	1.077	16.85
	Comanche	2	FF Baghouse	7.8487	4205	6.291	2.8139	2.661	75.14	62.26	0.374		62.26

Table B–8. List of Best Performing Units under various Ranking Scenarios

Coal Rank	Plant ID	Unit Number	Technology Control Type	Scenario 1: Average Outlet Emission, lb Hg/TBtu	Scenario 2: Average % Hg Reduction Across All Control Device(s)	Scenario 3: Average Outlet Emission (lb Hg/TBtuCoal) and % Hg Reduction Across All Control Device(s)	Scenario 4: Average Outlet Emission, lb Hg/TBtu	Scenario 5: Average % Hg Reduction Coal to Stack	Scenario 6: Average Outlet Emission (lb Hg/TBtuCoal) and % Hg Reduction Coal to Stack	Preliminary Data Quality Flag (Max. per run)	#times unit is 3rd pick
BITUMINOUS	Mecklenburg Cogeneration Facility	GEN 1	SDA/FF	3	2	3	1	3	1	2.0	3
	Dwayne Collier Battle Cogeneration	2B	SDA/FF	1	6	1	2	6	2	3.0	0
	Valmont	5	FF Baghouse	2	9	2	3	11	3	3.0	2
	SEI - Birchwood Power Facility	1	SCR/SDA/FF	5	3	5	4	5	4	2.0	1
	Logan Generating Plant	Gen 1	SCR/SDA/FF	4	1	4	5	1	5	1.0	0
	Intermountain	2SGA	FF/Wet FGD Scrubber	7	5	7	6	4	6	2.0	0
	Clover Power Station	2	FF/Wet FGD Scrubber	8	4	8	8	2	8	1.0	0
Lignite	Antelope Valley Station	B1	SDA/FF	3	6		1	3	1	2.0	2
	Stanton Station	1	CS-ESP	5	8		2	1	2	2.0	0
	Leland Olds Station	2	CS-ESP	2	5		3	5	3	3.0	2
	Bay Front Plant Generating	5	Mechanical Collector	1	11		4	11		3.0	0
	Stanton Station	10	SDA/FF	4	7		5	7		3.0	0
	Lewis & Clark	B1	PS/Wet FGD Scrubber	6	3	1	6	8		2.0	1
	Limestone	LIM1	CS-ESP/Wet FGD Scrubber	8	1	2	7	2	4	2.0	0
	Coyote	1	SDA/FF	7	4		8	10		2.0	0
	Monticello	3	CS-ESP/Wet FGD Scrubber	9	2	3	9	4	5	3.0	1
Lignite North	Antelope Valley Station	B1	SDA/FF	3	4		1	2	1	2.0	1
	Stanton Station	1	CS-ESP	5	6		2	1	2	2.0	0
	Leland Olds Station	2	CS-ESP	2	3		3	3	3	3.0	4
	Bay Front Plant Generating	5	Mechanical Collector	1	7		4	7		3.0	0
	Stanton Station	10	SDA/FF	4	5		5	4		3.0	0
	Lewis & Clark	B1	PS/Wet FGD Scrubber	6	1	1	6	5		2.0	0
	Coyote	1	SDA/FF	7	2		7	6		2.0	0

Scenario 1+4: Best Performing Units as Ranked by Lowest Total Hg Emission (lb/TBtu)
Scenario 2: Best Performing Units as Ranked by Highest Percent Reduction of Mercury Across Control Device(s)
Scenario 3: Best Performing Units as Ranked by Lowest Total Hg Emission (lb/TBtu) and having at least 20% Reduction of Mercury Across Control Device(s)
Scenario 5: Best Performing Units as Ranked by Highest Percent Reduction of Mercury from Coal to Stack
Scenario 6: Best Performing Units as Ranked by Lowest Total Hg Emission (lb/TBtu) and having at least 20% Reduction of Mercury from Coal to Stack
Scenarios 1-3 are based on a combined EMF approach to emission measurement
Scenarios 4-6 are determined from coal mercury content to final emissions

Table B–8. List of Best Performing Units under various Ranking Scenarios (continued)

Coal Rank	Plant ID	Unit Number	Technology Control Type	Scenario 1: Average Outlet Emission, lb Hg/TBtu	Scenario 2: Average % Hg Reduction Across All Control Device(s)	Scenario 3: Average Outlet Emission (lb Hg/TBtuCoal) and % Hg Reduction Across All Control Device(s)	Scenario 4: Average Outlet Emission, lb Hg/TBtu	Scenario 5: Average % Hg Reduction Coal to Stack	Scenario 6: Average Outlet Emission (lb Hg/TBtuCoal) and % Hg Reduction Coal to Stack	Preliminary Data Quality Flag (Max. per run)	#times unit is 3rd pick
Lignite South	Limestone	LIM1	CS-ESP/Wet FGD Scrubber	1	1	1	1	1	1	2.0	0
	Monticello	3	CS-ESP/Wet FGD Scrubber	2	2	2	2	2	2	3.0	0
	Big Brown	1	CS-ESP/FF (COHPAC)	3	3		3	3		2.0	4
	Monticello	1	CS-ESP/FF (COHPAC)	4	4		4	4		3.0	0
SUBBITUMINOUS	Clay Boswell	2	FF Baghouse	2	1	2	1	2	1	1.0	0
	Craig	C3	SDA/FF	1	6	1	2	15		3.0	0
	Cholla	3	HS-ESP	3	20		3	1	2	2.5	2
	Presque Isle	9	HS-ESP	16	22		4	10	3	2.0	1
	Craig	C1	HS-ESP/Wet FGD Scrubber	4	11		5	8	4	2.0	0
	Coronado	U1B	HS-ESP/Wet FGD Scrubber	5	24		6	17		2.0	0
	Comanche	2	FF Baghouse	7	2	3	7	4	5	1.0	1
	Laramie River Station	3	CS-ESP/SDA	9	5	4	10	5	8	3.0	0
	Laramie River Station	1	CS-ESP/Wet FGD Scrubber	10	3	5	11	6	9	3.0	1
	Montrose	1	CS-ESP	18	16		19	3	11	3.0	1
	Wyodak	BW 91	CS-ESP/SDA	21	4	8	23	26		2.0	0

Scenario 1+4: Best Performing Units as Ranked by Lowest Total Hg Emission (lb/TBtu)
Scenario 2: Best Performing Units as Ranked by Highest Percent Reduction of Mercury Across Control Device(s)
Scenario 3: Best Performing Units as Ranked by Lowest Total Hg Emission (lb/TBtu) and having at least 20% Reduction of Mercury Across Control Device(s)
Scenario 5: Best Performing Units as Ranked by Highest Percent Reduction of Mercury from Coal to Stack
Scenario 6: Best Performing Units as Ranked by Lowest Total Hg Emission (lb/TBtu) and having at least 20% Reduction of Mercury from Coal to Stack
Scenarios 1-3 are based on a combined EMF approach to emission measurement
Scenarios 4-6 are determined from coal mercury content to final emissions

Table B–9. List of Best Performing Units under various Ranking Scenarios (with data quality flag less than 3)

Coal Rank	Plant ID	Unit Number	Technology Control Type	Scenario 1: Average Outlet Emission, lb Hg/TBtu	Scenario 2: Average % Hg Reduction Across All Control Device(s)	Scenario 3: Average Outlet Emission (lb Hg/TBtuCoal) and % Hg Reduction Across All Control Device(s)	Scenario 4: Average Outlet Emission, lb Hg/TBtu	Scenario 4: Average Outlet Emission, lb Hg/TBtu	Scenario 6: Average Outlet Emission (lb Hg/TBtuCoal) and % Hg Reduction Coal to Stack	Preliminary Data Quality Flag (Max. per run)	#times unit is 3rd pick
BITUMINOUS	Mecklenburg Cogeneration Facility	GEN 1	SDA/FF	1	2	1	1	3	1	2.0	1
	SEI - Birchwood Power Facility	1	SCR/SDA/FF	3	3	3	2	5	2	2.0	3
	Logan Generating Plant	Gen 1	SCR/SDA/FF	2	1	2	3	1	3	1.0	2
	Intermountain	2SGA	FF/Wet FGD Scrubber	5	5	5	4	4	4	2.0	0
	Salem Harbor	3	SNCR/CS-ESP	4	7	4	5	7	5	1.0	0
	Clover Power Station	2	FF/Wet FGD Scrubber	6	4	6	6	2	6	1.0	0
Lignite	Antelope Valley Station	B1	SDA/FF	1	4		1	3	1	2.0	1
	Stanton Station	1	CS-ESP	2	5		2	1	2	2.0	0
	Lewis & Clark	B1	PS/Wet FGD Scrubber	3	2	1	3	5		2.0	2
	Limestone	LIM1	CS-ESP/Wet FGD Scrubber	5	1	2	4	2	3	2.0	1
	Coyote	1	SDA/FF	4	3		5	6		2.0	1
	Big Brown	1	CS-ESP/FF (COHPAC)	6	6		6	4		2.0	0
Lignite North	Antelope Valley Station	B1	SDA/FF	1	3		1	2	1	2.0	1
	Stanton Station	1	CS-ESP	2	4		2	1	2	2.0	0
	Lewis & Clark	B1	PS/Wet FGD Scrubber	3	1	1	3	3		2.0	3
	Coyote	1	SDA/FF	4	2		4	4		2.0	0
Lignite South	Limestone	LIM1	CS-ESP/Wet FGD Scrubber	1	1	1	1	1	1	2.0	0
	Big Brown	1	CS-ESP/FF (COHPAC)	2	2		2	2		2.0	0
SUBBITUMINOUS	Clay Boswell	2	FF Baghouse	1	1	1	1	2	1	1.0	0
	Cholla	3	HS-ESP	2	11		2	1	2	2.5	0
	Presque Isle	9	HS-ESP	11	12		3	6	3	2.0	2
	Craig	C1	HS-ESP/Wet FGD Scrubber	3	6		4	4	4	2.0	1
	Coronado	U1B	HS-ESP/Wet FGD Scrubber	4	13		5	11		2.0	0
	Comanche	2	FF Baghouse	6	2	2	6	3	5	1.0	1
	Navajo	3	HS-ESP/Wet FGD Scrubber	5	7		8	5	7	2.0	0
	Sam Seymour	3	CS-ESP/Wet FGD Scrubber	15	5	5	9	8		2.0	0
	Rawhide	101	SDA/FF	14	4	4	13	14		2.0	0
	Wyodak	BW 91	CS-ESP/SDA	12	3	3	14	15		2.0	2

Footnotes for Table B–9:

Scenario 1+4: Best Performing Units as Ranked by Lowest Total Hg Emission (lb/TBtu)

Scenario 2: Best Performing Units as Ranked by Highest Percent Reduction of Mercury Across Control Device(s)

Scenario 3: Best Performing Units as Ranked by Lowest Total Hg Emission (lb/TBtu) and having at least 20% Reduction of Mercury Across Control Device(s)

Scenario 5: Best Performing Units as Ranked by Highest Percent Reduction of Mercury from Coal to Stack

Scenario 6: Best Performing Units as Ranked by Lowest Total Hg Emission (lb/TBtu) and having at least 20% Reduction of Mercury from Coal to Stack

Scenarios 1-3 are based on a combined EMF approach to emission measurement

Scenarios 4-6 are determined from coal mercury content to final emissions

Appendix C. Summary of Operations at Best Performing Units

This appendix includes brief summary material regarding the units selected as representative units for ranking Scenario 6 [lowest total mercury emission (coal-to-stack) *and* 20 percent mercury reduction]. This information is provided solely for additional insight into the types and configurations of units tested and issues encountered during the ICR Phase III field testing activities. While review of the detailed facility test reports has indicated potentially significant issues pertaining to unit sampling and possibly even data validity, nothing was done in this analysis that altered or adjusted the data used. Data used for algorithm development was taken "as published" from the most recent data source in which it was available. The three sources of plant-level ICR Phase III data are:

1. Kilgroe, J. D. et.al.; Control of Mercury Emissions from Coal-Fired Electric Utility Boilers: Interim Report Including Errata Dated 3-21-02, EPA-600/R-01-109, April 2002.

2. Extracted Data (rawdata.xls), Downloaded from the EPA Electric Utility Steam Generating Units Section 112 Rule Making website: (http://www.epa.gov/ttn/atw/combust/utiltox/ rawdata1.xls).

3. Control Device Analysis (Bin Table.xls), Downloaded from the EPA Electric Utility Steam Generating Units Section 112 Rule Making website: (http://www.epa.gov/ttn/atw/combust/utiltox/control2.zip).

PG&E Generating Company, Logan Generating Station Unit 1

Logan Generating Station Unit 1 is a 230 MW pulverized coal-fired cogeneration facility that exports 50,000 lbs/hour of steam to a host facility. The unit burns ~1 percent sulfur bituminous coal and is equipped with selective catalytic reduction (SCR), low NOx burners and overfire air for NOx control and a lime injection spray dryer absorber (SDA) /fabric filter (FF) baghouse for SO2 and particulate control. Testing was conducted at steady-state load conditions representing maximum capacity (+/- 5 percent) of the source being tested.

Testing was carried out in August 1999, with the mercury emissions testing program conducted by TRC Environmental Corporation. Analytical testing was conducted at two laboratories [Phillips Analytical Services Corporation (PSC) for Ontario-Hydro (O-H) mercury train samples and Commercial Testing and Engineering for as-fired coal samples and flue-gas desulfurization samples]. O-H sampling was conducted using the EPA draft method released July 7, 1999. The initial report was submitted to EPA on November 24, 1999 but due to calculation errors that occurred at PSC, a corrected report was submitted to EPA on January 21, 2000. The January 2000 report is the basis of this summary.

According to the submitted report, TRC considered their efforts satisfactory in meeting the requirements for data collection. Several problems were noted during the testing protocol but considered insignificant in the project outcome. Problems included high negative static pressure encountered at the SDA inlet which required modification of the sample train procedure for each sample port (initiation of sampling prior to insertion and termination of sampling only after nozzle had exited sampling port). Additional reported problems included a malfunctioning dry gas meter and loss of inlet train nozzles either by separation or breakage. In the above-described problems, corrective actions in the field were considered satisfactory by TRC and the impact to overall sampling activities was considered insignificant.

In addition to the problems occurred during sampling activities, analysis of paired sample trains produced results that demonstrated large variation among a number of pairs. Of the 18 sample pairs analyzed, 5 pairs demonstrated significant variation between the two measured values. Although three of the five pairs included measurements of elemental mercury below the detection limit, the remaining two pairs were measurements of oxidized mercury at relatively high concentrations. The analysis team confirmed analytical and sampling conditions and upon determining that no significant differences existed, evaluated the data "on a statistical basis." The analysis team determined for all five pairs the higher value of the two was an outlier, and results were reported for the "valid" data only. While no precision criteria were stated in the QA plan, the investigators used a self-imposed limit of 50 percent relative percent difference as an indicator for loss in precision. It was a conclusion of the analysis team that because of the presence of high RSDs, a possible precision problem may exist with the method used. [Note: According to the RTI website (http://utility.rti.org/part3/faqP3_2.cfm#ques3), while initially paired sampling was a requirement, it was later determined that single sampling trains only were required at both the inlet and outlet of the tested control device.]

Reliant Energy Incorporated, Limestone Electric Generating Station Unit 1

Limestone Electric Generating Station Unit 1 is an 820 MW tangentially-fired lignite burning unit. The unit is equipped with a cold-side electrostatic precipitator for particulate control and an inhibited oxidation wet flue gas desulfurization (FGD) system. The FGD reagent is ground limestone slurry with dibasic acid additive. Testing was conducted at near full-load conditions at minimum approximately 90 percent of maximum capacity.

Testing was carried out on November 16, 1999, with the mercury emissions testing program conducted by Radian International, and analytical testing was conducted at Severn Trent Laboratories. Ontario-Hydro sampling was conducted using the EPA draft method released July 7, 1999. The final report was submitted to EPA on February 28, 2000.

According to the submitted report, Radian International considered their efforts satisfactory in meeting the requirements for data collection. Sampling occurred across Absorber "A", one of four absorbers normally in operation at the facility (a fifth absorber is typically on standby). The report notes that measured outlet flow rate was insufficient to produce a reliable mercury mass flow rate at the outlet. Additionally, a small amount of flue gas was bypassed around the wet FGD system (~4 percent). The test report includes adjustments to compensate for the bypassed flue gas.

Paired sampling also was conducted at Limestone Electric Generating Station but results were much more consistent than those reported for Logan Generating Station. However, a sampling issue was identified for the O-H method during an analysis of an NIST standard ash sample. Duplicate analysis of two aliquots of the standard ash sample resulted in average concentrations ranging from 2x to 7x the certified value of the standard. The variability was attributed to analytical technique differences, where O-H samples are analyzed using CVAA and the coal standard is certified by NIST using ICP and ID-TMS. Because for this facility the particulate bound fraction contributed on average less than 0.5 percent of the total mercury found in the flue gas, the analytical team considered the discrepancy to have an insignificant effect on the determination of gas-phase mercury concentration, mercury control efficiency, or mercury emission rate. Additionally, laboratory analysis of a coal standard for mercury content resulted in a value approximately 56 percent of the certified value. However, the investigators considered the measurement of the coal samples from the unit acceptable since they fell within the range typical for Texas lignite.

Wisconsin Electric Power Company, Presque Isle Power Plant Unit 9

Presque Isle Power Plant Unit 9 is an 88 MW subbituminous-fired unit. The unit is equipped with a hot-side ESP for particulate control. Testing was conducted at or near full-load conditions at an average of 95 percent of maximum capacity.

Testing was carried out from July 12 to July 20, 1999, with the mercury emissions testing program conducted by Roy F. Weston, Inc. Analytical testing was conducted by two additional participants, the Energy & Environmental Research Center (EERC), which performed mercury sample analysis and also operated additional continuous mercury emission monitoring systems and CONSOL, R&D, which was responsible for collection and analysis of coal and also ash samples. The final report was submitted to EPA on November 15, 1999.

The sampling and analysis was considered successful by the project team. Few problems were identified in the report but sampling upstream of the hot side ESP did not meet EPA Method 1 criteria (ports were located <1.0 diameters upstream and downstream of the nearest gas flow disturbances. Because the sampling site was considered the only test location at the inlet suitable for sampling, samples were taken at that location. As described in Section 4 of this report, EPA did not require that sampling ports meet Method 1 criteria.

Sampling at Presque Isle Unit 9 did not include paired sample trains. Also, while the initial test plan included a provision that all flue gas samples were to be measured in duplicate using CVAA and every 10th sample be measured in triplicate, EERC felt that from their experience, duplicate testing of each individual sample was unnecessary once a mercury sample had been prepared. However, EERC did adhere to the 1 in 10 triplicate analysis requirement. EERC also performed additional QA/QC measures that indicated for those tests that equipment and procedures were within their internally prescribed limits. In addition to flue gas sampling, fly ash sampling and analysis was also conducted to estimate a material balance closure for Unit 9, based on coal mercury input and measured flue gas mass flow at the collection device outlet. It should be noted that information provided in the site test report estimated coal-to-stack removal of approximately 12.7 percent, somewhat lower than that reported by EPA of approximately 25.7 percent.

Appendix D. Additional Sample Calculations

Sample Calculation: Calculation of average outlet emission for Scenarios 1 and 4 and identification of percent mercury reduction for Scenarios 2 and 5.

In Chapter 3, units are ranked based on their performance towards emitting low rates of mercury or reducing the air emissions of mercury through control devices. These values were calculated from EPA ICR-III data in the following manner. Sample values are provided for the Mecklenberg Cogeneration Facility (burning bituminous coal with an SDA/FF control device).

<u>Scenarios 2 and 5</u>

Values for average percent mercury reduction are taken directly from the 2002 EPA report (Control of Mercury Emissions from Coal-fired Electric Utility Boilers: Interim Report Including Errata Dated 3-21-02, OAQPS/USEPA, EPA-600/R-01-109, April 2002). For example, for Mecklenberg values are presented in Table 6-15 of this report:
Scenario 2: % Reduction (OH) = 97.91%
Scenario 5: % Reduction (Coal-to-Stack) = 98.07%

In cases where additional control devices are present at a particular unit, average emission modification factors (EMF) specific to the preceding control device are taken from the EPA report.

<u>Scenario 1</u>

Source values:
Average Hg outlet emission at Mecklenberg, ug/dscm @ 3% O2: 0.24 (from Table 6-15 of 2002 EPA Report)
F-Factor: 9840 (constant, used for all units)
Conversion factor, dscf to dscm: 0.02831685
Adjustment to 3% oxygen: 20.9/(20.9-3)
Conversion from ug to pounds: 453.6

Emission rate, lb Hg / TBtu = 0.24 * 9840 * 0.02831685 * 20.9/(20.9-3) / 453.6

Average Emission rate at Mecklenberg = 0.1697 lb Hg/TBtu

<u>Scenario 4</u>

Source values (all data from rawdata1.xls specific to Mecklenberg):
Average Hg outlet emission, ug/dscm: 0.114 (run 1); 0.110 (run 2); 0.085 (run 3). NDs are evaluated at ½ detection limit. These are different than the EPA report data because these are not corrected to oxygen
Outlet flow rate (dscm/hr): 271,499 (run 1); 275,747 (run 2); 272,009 (run 3)
HHV Coal heating value (Btu/lb): 14,042 (run 1); 13,877 (run 2); 13,867 (run 3)
Coal flow rate (kg/hr, dry): 25,138 (run 1); 26,151 (run 2); 25,488 (run 3)
Conversion factor: 1,000

Emission rate, lb Hg / TBtu = 1,000 * [Hg emission] * [outlet flow]/(HHV * coal flow}]

Emission rates for each run:
Run 1, lb Hg/ TBtu = 1,000 * 0.114 * 271,499 / (14,042 * 25,138) = 0.114

Run 2, lb Hg/ TBtu = 0.110
Run 3, lb Hg/ TBtu = 0.085

Average Emission at Mecklenberg = (0.114 + 0.110 + 0.085)/3 = 0.103 lb Hg / TBtu

Sample Calculation: Unit Conversion for Ontario-Hydro Method

In Chapter 4, uncertainty related to the Ontario-Hydro method is presented (where mercury measurements are in units of ug/Nm3). The emissions in units of lb/TBtu were converted to concentration using a similar method as shown above for Scenario 1, with an additional conversion from dscm to Nm3.

Example calculation, Mecklenberg Scenario 5 (Table 4-5)

Source values:
Calculated initial (test) emission, lb Hg/TBtu = 0.103 (calculated above)
F-Factor: 9840 (constant, used for all units)
Conversion factor, dscm to dscf: 35.31
Adjustment from 3% oxygen: (20.9-3)/20.9
Conversion from ug to pounds: 453.6
Conversion 1 Nm3 = 0.9479 dscm

Emission rate, ug/ Nm3 = 0.103 * (1/9840) * 35.31 * (20.9-3)/20.9 *453.6 * 0.9479

Corresponding Calculated Average Emission rate at Mecklenberg = 0.14 ug/ Nm3

Appendix E. Estimating Analysis Variability in Ontario-Hydro Method

ASTM D 6784-02 (the published Ontario-Hydro Method) includes precision and bias data that allow for an estimate of uncertainty associated with the results. These results are from the replicate sampling of a spiked flue gas stream for oxidized and elemental mercury. The results show that as concentration decreased, relative standard deviation (RSD) increased. These results were curve-fit to estimate reproducibility for the ICR-III values. The data were found to fit the following equation:

RSD = 0.5001 * [Mean Hg (ug/Nm3)]-0.571 R2= 0.9222

The data are shown in Table E–1 and are plotted in the graph below. The graph includes the curve fit.

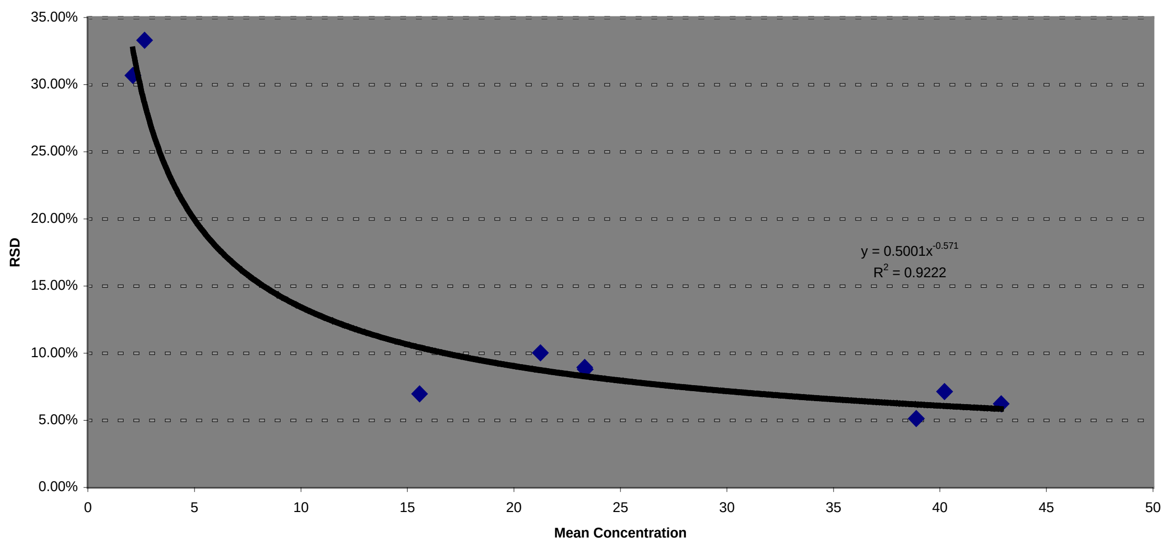
One shortcoming to this method is that the ASTM method includes mercury levels no lower than 2 ug/Nm3, whereas many of the stack test results are below this value. Therefore, there is considerable uncertainty in extrapolating these results to the lower concentrations measured in the ICR-III testing. For example, at 0.1 ug/Nm3 the RSD is 186 percent, a calculated RSD that is much higher than that in any of the source data.

Table E–1. Method Precision Data for Ontario-Hydro Method ASTM D 6784-02

Mean Hg, µg/Nm^3	Stdev	RSD (given)
23.35	2.05	8.79%
38.89	2	5.13%
42.88	2.67	6.23%
21.24	2.13	10.02%
23.32	2.08	8.94%
40.22	2.87	7.14%
2.11	0.65	30.69%
15.57	1.09	6.97%
2.66	0.89	33.31%

For each mean result there were 12 replicate samples.
1 Nm^3 = 0.9479 dscm

OH Measurement Precision



Appendix F. Estimating Analysis Variability in Feed Coal

Mercury analyses in feed coal are subject to variability. Errors in analysis result in deviations between the coal's reported mercury value and its "true" value (which is never known with absolute certainty). Several resources available to assess the variability from analysis are presented here.

USGS analyzed samples of coal using cold vapor atomic absorption spectrometry. This is the method used by the vast majority of facilities in both the ICR-II and ICR-III data collection efforts. USGS reports that the long-term method precision is 5 to 10 percent over the range of 0.05 to 0.5 parts per million (ppm) with a detection limit of 0.01 parts per million. USGS presented their own analyses of mercury in coal, reporting values of 110 and 400 ppm and precision in the 5 to 10 percent range[13].

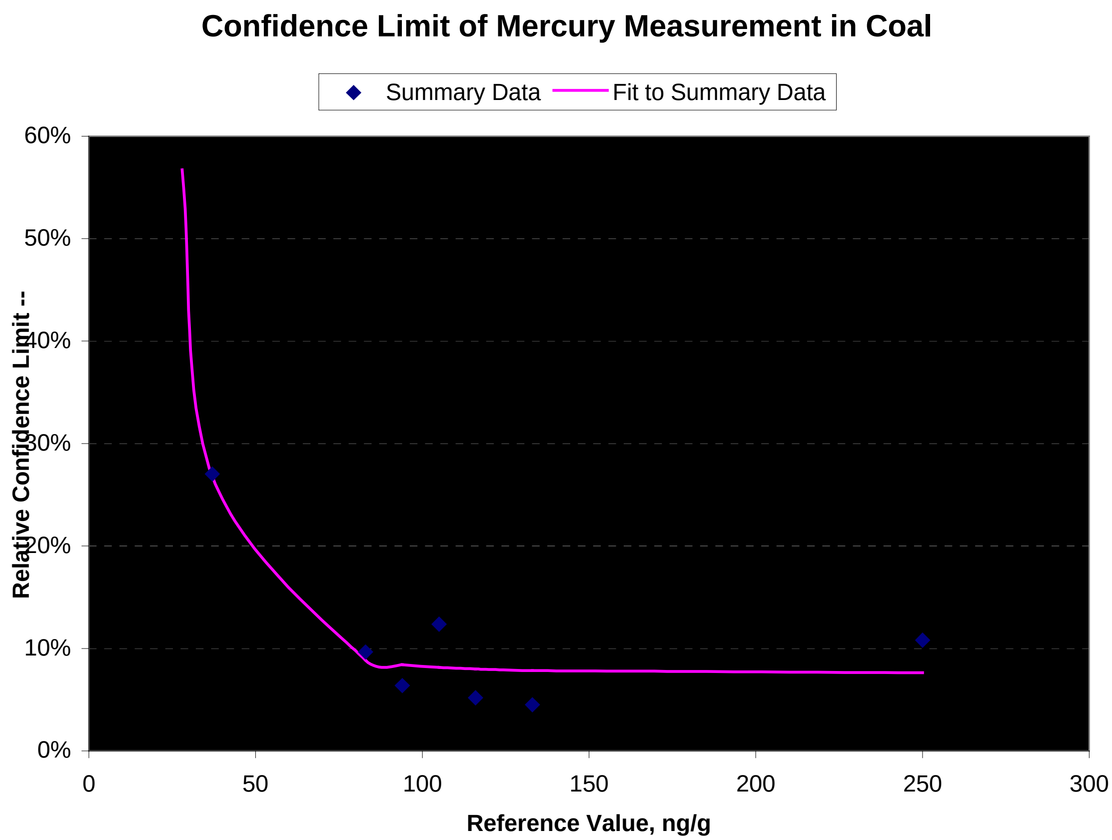
The Canadian government[14] sponsored an evaluation to assess the precision of Canadian laboratories in measuring mercury in coal. Precision was measured through the analysis of seven types of coal by 13 laboratories. The mercury concentrations of the coal ranged from 0.037 to 0.25 ppm. The relative confidence limit, in accounting for variability between laboratories and conditions, ranged from 5 to 27 percent. The lowest mercury level has the highest relative confidence limit (RCL). The data were found to fit the following equation:

RCL = 0.0758 + 36392.661 * [Mean Hg (ug/g)]-3.365 R2= 0.983

The source data are shown in Table F–1 and are plotted in the graph below. The graph includes the curve fit. As shown in the graph, the relative standard deviation rises steeply with decreasing mercury concentration. For example, a sample with 0.04 ppm mercury is projected to have an RCL of 22 percent, while a sample with 0.01 ppm mercury is projected to have an RCL of 1600 percent, corresponding to upper confidence limits of 0.05 and 0.16 ppm, respectively. Therefore, an obvious shortcoming to using the above equation to predict relative confidence limit for very low concentrations of mercury in coal is insufficient data to verify the very high predicted RCL values. The above equation is particularly uncertain for coal concentrations at concentrations below the lowest mercury value for which source data are available, i.e., 37 ppb.

The predicted variability of the ICR-III measured mercury concentrations are presented in Chapter 4 of the report.

[13] The Determination of Mercury in Whole Coal by Cold Vapor Atomic Absorption Spectrometry. In Methods for Sampling and Inorganic Analysis of Coal, USGS Bulletin 1823 by D.W. Golighty and F.O. Simon (editors).
[14] Mercury Laboratory Round Robin Project CCME/CEA Project 257-2003: Phase 1 CRM/RM Sample Report.



Confidence Limit of Mercury Measurement in Coal
Summary Data
Fit to Summary Data
60%
50%
40%
30%
20%
10%
0%
Relative Confidence Limit --
0
50
100
150
200
250
300
Reference Value, ng/g

Table F–1. Comparison of CCME/CEA Mercury Values with Reference Mercury Values

Source	Sample	Sample Type	Reference Value	Reference CL	CCME Median	CCME CL	Horrat CL	Combined CL	Comb CL to Ref Value
ASTM	ES-3	HV B Bituminous Coal	37	8	36	3	4	10	27.03%
ASTM	ES-4	Subbituminous Coal	83	5	86	5	7	8	9.64%
NIST	1632c	HV A Bituminous Coal	94	4	91	4	7	6	6.38%
ASTM	ES-5	Lignite Coal	105	9	118	8	8	13	12.38%
ASTM	ES-2	HV B Bituminous Coal	116	4	120	3	9	6	5.17%
NIST	2692b	HV A Bituminous Coal	133	4	125	3	10	6	4.51%
SABS	SARM-20	HV C Bituminous Coal	250	23	244	7	16	27	10.80%

Source: CCME data. Mercury concentrations ng/g (ppb).

Appendix G. Development of Algorithms for Pollution Control Equipment

Algorithms were developed to correlate the mercury removal efficiency of a control device with properties of the coal. The purpose of the algorithms is to estimate variability in the baseline MACT floor values. These algorithms were developed for each type of control device combination identified during ICR-III testing (for which sufficient data were available). Segregation by coal type was not conducted, due to a lack of data sufficient to develop a correlation.

Table G–1 lists the types of control devices found during the ICR-III testing. Table G–1 does not include the facilities that were excluded from the baseline MACT floor analysis (e.g., FBC boilers). Table G–1 has the following columns:

- *Techtype*: Identifies the principal control device(s) being evaluated.
- *Techtype1, PMControl, SO2Control, ExtNOxControl*: Identifies additional details regarding how particulate matter, sulfur dioxide and nitrogen oxides are controlled.
- *Frequency and Percent*: Identifies the number (and percent, respectively) of ICR-3 test runs available for the particular control equipment.
- *Cumulative Frequency and Cumulative Percent*: Identifies the cumulative number (and percent, respectively) of ICR-III test runs available for all control equipment.

Table G–1 provides 19 different control device combinations, each represented by a single line. Table G–2 combines some of the similar control devices into single categories (i.e., based on Techtype). The 19 different combinations in Table G–1 are reduced to 14 combinations in Table G-2 based on the following:

Distinctions in compliance coal (Comp. Coal) as an SO2 control were ignored.

- The data points for particulate scrubber/ wet FGD scrubber were combined, due to similarities in the listed particulate control devices.
- The effect of selective catalytic reduction (SCR) prior to the spray dryer adsorption/ fabric filter was ignored, in order to increase the available data on which to base an algorithm for SDA/ FF.
- The data associated with the use of selective noncatalytic reduction (SNCR) prior to a cold side ESP were not combined with the remaining CS-ESP data, because sufficient data on cold side ESP devices were available to base an algorithm.

Of the 14 combinations in Table G–2, sufficient data were available to develop a correlation for only seven. For these seven technologies, at least 12 data points (represented by at least four facilities) were present. For the remaining technologies, data for less than four facilities were available. Four facilities was considered the minimum for developing an algorithm; the more facilities the better the algorithm. The seven control technologies used in this analysis for algorithm development are listed in Table G–3.

Table G–4 provides the algorithms developed. The dependent variable was the value log (100% - % Reduction), which corresponds to percent mercury emitted across the control. Using the log of this value is appropriate because the data were found to have a logarithmic distribution. The independent variables were coal chlorine content and the ratio of chlorine to sulfur in the coal. These algorithms were based on the ICR-III data. For each control device, four algorithms were developed: two each for log-linear relationships and two each for log-log relationships. Table G–4 lists the coefficients calculated for these algorithms based on a straight line fit (y = mx + b), where y is the dependent value of log (100% - % Reduction), x is the independent variable (e.g., log chlorine content), m is the coefficient for the respective independent variable, and b is the intercept. The calculated R-squared value is shown for each algorithm. Higher values of R-squared (i.e., those approaching 1) indicate a better correlation of the algorithm model with the source data. Therefore, the single algorithm with the highest R-squared was selected from these four algorithms for further predictive calculations as discussed in Chapter 4 of this report. For FF/Baghouse, each of the models gives only small differences in the R-squared value indicating similar model performance. Therefore, for this control technology, Model 1 was selected for simplicity and because Model 1 was found to be best for most (i.e., three of six) other control technologies.

A correction in the source data was made prior to developing the algorithms. The heating value of the coal used at Coyote, Run # 2, was adjusted from 106.73 Btu/lb to 10,673 Btu/lb. The former value was unreasonably low; the data in the facility's speciated mercury emissions testing report verifies the corrected value.

Tables G–5 through G–7 present the calculated percent reduction using three different concentration inputs (corresponding to the ICR-III value, the 95th ICR-II value, and the plant average ICR-II value, respectively). Table G–8 calculates the resultant change in the mercury MACT floor by using the ratio of the calculated values.

Graphs of the source data and the algorithms are presented in Figures G–1 through G–7. These plots show the value log (100% - % Reduction) versus ln (chlorine content) for each of the seven control technologies. The graphs serve to illustrate the data available for each control technology, and the "scatter" within the data set.

Table G–1. Listing of All Control Technologies

The FREQ Procedure

TECHTYPE	TECHTYPE1	Frequency	Percent	Cumulative Frequency	Cumulative Percent
CS-ESP	CS-ESP	12	18.46	12	18.46
CS-ESP/FF (COHPAC)	CS-ESP/FF (COHPAC)	2	3.08	14	21.54
CS-ESP/SDA	CS-ESP/SDA	3	4.62	17	26.15
CS-ESP/Wet FGD	CS-ESP/Wet FGD Scrubber	7	10.77	24	36.92
CS-ESP/Wet FGD	CS-ESP/Wet FGD Scrubbers	1	1.54	25	38.46
DSI/CS-ESP	DSI/CS-ESP	1	1.54	26	40.00
FF Baghouse	FF Baghouse	4	6.15	30	46.15
FF/Wet FGD Scrubber	FF/Wet FGD Scrubber	2	3.08	32	49.23
HS-ESP	HS-ESP	7	10.77	39	60.00
HS-ESP/Wet FGD Scrubber	HS-ESP/Wet FGD Scrubber	6	9.23	45	69.23
Mechanical Collector	Mechanical Collector	1	1.54	46	70.77
PM Scrubber	PM Scrubber	1	1.54	47	72.31
PS/Wet FGD	PS/Wet FGD Scrubber	6	9.23	53	81.54
PS/Wet FGD	PS/Wet FGD Scrubbers	1	1.54	54	83.08
SDA/FF	SCR/SDA/FF	2	3.08	56	86.15
SDA/FF	SDA/FF	8	12.31	64	98.46
SNCR/CS-ESP	SNCR/CS-ESP	1	1.54	65	100.00

Table G–2. Control Technology Type

TECHTYPE	Frequency	Percent	Cumulative Frequency	Cumulative Percent
CS-ESP	12	18.46	12	18.46
CS-ESP/FF (COHPAC)	2	3.08	14	21.54
CS-ESP/SDA	3	4.62	17	26.15
CS-ESP/Wet FGD	8	12.31	25	38.46
DSI/CS-ESP	1	1.54	26	40.00
FF Baghouse	4	6.15	30	46.15
FF/Wet FGD Scrubber	2	3.08	32	49.23
HS-ESP	7	10.77	39	60.00
HS-ESP/Wet FGD Scrubber	6	9.23	45	69.23
Mechanical Collector	1	1.54	46	70.77
PM Scrubber	1	1.54	47	72.31
PS/Wet FGD	7	10.77	54	83.08
SDA/FF	10	15.38	64	98.46
SNCR/CS-ESP	1	1.54	65	100.00

Table G–3. Listing of Control Technologies used in this Analysis

Technology Control Type	Number of Facilities
CS-ESP	12
CS-ESP/Wet FGD	8
FF Baghouse	4
HS-ESP	7
HS-ESP/Wet FGD Scrubber	6
PS/Wet FGD	7
SDA/FF	10
	==========
	54

Table G–4. Summary of Algorithms by Control Technology

Technology Control Type	Label of model	Root mean squared error	Intercept	LN(Chlorine in lb/TBtu)	LN(Chlorine in ppm)	Average Chlorine content of the coal/fuel sample, lb/TBtu	Average Chlorine content of the coal/fuel sample,in mg/kg or ppm(dry basis)	Average Chlorine to Sulfur Ratio, lb/TBtu	LN(Chlorine (TBtu)/ Sulfur(MBtu)	Number of regressors in model	Number of parameters in model	Error degrees of freedom	R-squared
CS-ESP	Model1	0.337	-1.6374	0.18693						1	2	10	0.38
	Model2	0.311	0.0773			.000003309				1	2	10	0.47
	Model3	0.248	-0.0310					0.000003929		1	2	10	0.66
	Model4	0.336	-1.9547						0.208	1	2	10	0.38
CS-ESP/Wet FGD	Model1	0.272	-1.8529	0.27149						1	2	6	0.74
	Model2	0.274	0.4224			.000008876				1	2	6	0.73
	Model3	0.274	0.2559					0.000023343		1	2	6	0.73
	Model4	0.349	-2.7630						0.367	1	2	6	0.57
FF Baghouse	Model1	0.583	-0.8194	0.29335						1	2	2	0.50
	Model2	0.552	1.5447			.000010953				1	2	2	0.55
	Model3	0.553	1.4742					0.000010815		1	2	2	0.55
	Model4	0.593	-2.0838						0.401	1	2	2	0.48
HS-ESP	Model1	0.133	-0.9451	0.09995						1	2	5	0.42
	Model2	0.097	-0.0759			.000003816				1	2	5	0.69
	Model3	0.119	-0.0611					0.000002169		1	2	5	0.54
	Model4	0.137	-1.1652						0.116	1	2	5	0.39
HS-ESP/Wet FGD Scrubber	Model1	0.128	-2.7019	0.29952						1	2	4	0.75
	Model2	0.148	0.0359			.000009358				1	2	4	0.67
	Model3	0.186	-0.0217					0.000006561		1	2	4	0.48
	Model4	0.196	-2.5618						0.268	1	2	4	0.42
PS/Wet FGD	Model1	0.233	-0.4685	0.05793						1	2	5	0.07
	Model2	0.237	0.0366			.000002108				1	2	5	0.03
	Model3	0.234	0.1417					-.000003452		1	2	5	0.06
	Model4	0.241	0.3134						-.025	1	2	5	0.01
SDA/FF	Model1	0.653	-10.7111	1.22628						1	2	8	0.89
	Model2	0.708	0.0192			.000031418				1	2	8	0.87
	Model3	1.017	0.1070					0.000020452		1	2	8	0.73
	Model4	1.003	-8.8917						1.011	1	2	8	0.74

Model1: -LN(1 - Percent Reduction) as a function of LN(Chlorine)
Model2: -LN(1 - Percent Reduction) as a function of Chlorine
Model3: -LN(1 - Percent Reduction) as a function of Ratio Chlorine to Sulfur
Model4: -LN(1 - Percent Reduction) as a function of LN(ratio of Chlorine to Sulfur)
Note: No Valid algorithm could be found for PS/Wet FGD

Table G–5. Algorithm Calculations Using Sampled Chlorine and Sulfur Coal Content from ICR-III

Coal Rank	Scenario No	Plant ID	Unit Number	Technology Control Type	Average Sampled Coal at Plant, lb Cl/TBtu	Average Sampled Coal at Plant, ln(lb Cl/TBtu)	Average Sampled Coal at Plant, Cl/S MBtu/TBtu	Average Sampled Coal at Plant, lnCl/S MBtu/TBtu)	%Reduction, PModel1	%Reduction, PModel2	%Reduction, PModel3	%Reduction, PModel4
BITUMINOUS	1	SEI - Birchwood Power Facility	1	SDA/FF	73,100	11.20	115,109	11.65	0.9513	0.9013	0.9147	0.9444
	2	SEI - Birchwood Power Facility	1	SDA/FF	73,100	11.20	115,109	11.65	0.9513	0.9013	0.9147	0.9444
	3	SEI - Birchwood Power Facility	1	SDA/FF	73,100	11.20	115,109	11.65	0.9513	0.9013	0.9147	0.9444
	4	Logan Generating Plant	Gen 1	SDA/FF	109,006	11.60	136,840	11.83	0.9702	0.9681	0.9453	0.9533
	5	Mecklenburg Cogeneration Facility	GEN 1	SDA/FF	135,886	11.82	137,019	11.82	0.9772	0.9863	0.9455	0.9529
	6	Logan Generating Plant	Gen 1	SDA/FF	109,006	11.60	136,840	11.83	0.9702	0.9681	0.9453	0.9533
Lignite	2	Coyote	1	SDA/FF	9,189	9.13	6,011	8.67	0.3810	0.2650	0.2054	-0.1406
	5	Antelope Valley Station	B1	SDA/FF	10,417	9.25	9,619	9.16	0.4692	0.2928	0.2619	0.3082
Lignite North	2	Antelope Valley Station	B1	SDA/FF	10,417	9.25	9,619	9.16	0.4692	0.2928	0.2619	0.3082
SUBBITUMINOUS	1	Craig	C1	HS-ESP/Wet FGD Scrubber	21,531	9.98	49,956	10.81	0.2490	0.2113	0.2636	0.2833
	4	Presque Isle	9	HS-ESP	15,750	9.66	19,044	9.86	0.0206	-0.0159	-0.0200	-0.0259
	5	Comanche	2	FF Baghouse	4,205	8.34	11,628	9.36	0.8037	0.7962	0.7981	0.8120
	6	Presque Isle	9	HS-ESP	15,750	9.66	19,044	9.86	0.0206	-0.0159	-0.0200	-0.0259

Scenario 1+4: Best Performing Units as Ranked by Lowest Total Hg Emission (lb/TBtu)
Scenario 2: Best Performing Units as Ranked by Highest Percent Reduction of Mercury Across Control Device(s)
Scenario 3: Best Performing Units as Ranked by Lowest Total Hg Emission (lb/TBtu) and having at least 20% Reduction of Mercury Across Control Device(s)
Scenario 5: Best Performing Units as Ranked by Highest Percent Reduction of Mercury from Coal to Stack
Scenario 6: Best Performing Units as Ranked by Lowest Total Hg Emission (lb/TBtu) and having at least 20% Reduction of Mercury from Coal to Stack

Scenarios 1-3 are based on a combined EMF approach to emission measurement

Scenarios 4-6 are determined from coal mercury content to final emissions

Missing Scenarios result from fewer than 3 plants

Table G–6. Algorithm Calculations Using 95th percentile of Annual Average Chlorine and Sulfur Coal Content from ICR-II

Coal Rank	Scenario No	Plant ID	Unit Number	Technology Control Type	95th percentile of Annual Average Coal at All Plants, lb Cl/TBtu	95th percentile of Annual Average Coal at All Plants, ln(lb Cl/TBtu)	95th percentile of Annual Average Coal at All Plants, Cl/S MBtu/TBtu	95th percentile of Annual Average Coal at All Plants, lnCl/S MBtu/TBtu)	|	%Reduction, PModel1	%Reduction, PModel2	%Reduction, PModel3	%Reduction, PModel4
BITUMINOUS	1	SEI - Birchwood Power Facility	1	SDA/FF	17,560	9.77	9,110	9.12	|	0.7202	0.4350	0.2542	0.2776
	2	SEI - Birchwood Power Facility	1	SDA/FF	17,560	9.77	9,110	9.12	|	0.7202	0.4350	0.2542	0.2776
	3	SEI - Birchwood Power Facility	1	SDA/FF	17,560	9.77	9,110	9.12	|	0.7202	0.4350	0.2542	0.2776
	4	Logan Generating Plant	Gen 1	SDA/FF	17,560	9.77	9,110	9.12	|	0.7202	0.4350	0.2542	0.2776
	5	Mecklenburg Cogeneration Facility	GEN 1	SDA/FF	17,560	9.77	9,110	9.12	|	0.7202	0.4350	0.2542	0.2776
	6	Logan Generating Plant	Gen 1	SDA/FF	17,560	9.77	9,110	9.12	|	0.7202	0.4350	0.2542	0.2776
Lignite	2	Coyote	1	SDA/FF	10,150	9.23	8,840	9.09	|	0.4521	0.2869	0.2501	0.2553
	5	Antelope Valley Station	B1	SDA/FF	10,150	9.23	8,840	9.09	|	0.4521	0.2869	0.2501	0.2553
Lignite North	2	Antelope Valley Station	B1	SDA/FF	9,900	9.20	9,470	9.16	|	0.4351	0.2813	0.2597	0.3053
SUBBITUMINOUS	1	Craig	C1	HS-ESP/Wet FGD Scrubber	2,370	7.77	6,800	8.82	|	-0.4543	0.0565	0.0227	-0.2195
	4	Presque Isle	9	HS-ESP	2,370	7.77	6,800	8.82	|	-0.1835	-0.0691	-0.0475	-0.1557
	5	Comanche	2	FF Baghouse	2,370	7.77	6,800	8.82	|	0.7678	0.7921	0.7873	0.7668
	6	Presque Isle	9	HS-ESP	2,370	7.77	6,800	8.82	|	-0.1835	-0.0691	-0.0475	-0.1557

Scenario 1+4: Best Performing Units as Ranked by Lowest Total Hg Emission (lb/TBtu)
Scenario 2: Best Performing Units as Ranked by Highest Percent Reduction of Mercury Across Control Device(s)
Scenario 3: Best Performing Units as Ranked by Lowest Total Hg Emission (lb/TBtu) and having at least 20% Reduction of Mercury Across Control Device(s)
Scenario 5: Best Performing Units as Ranked by Highest Percent Reduction of Mercury from Coal to Stack
Scenario 6: Best Performing Units as Ranked by Lowest Total Hg Emission (lb/TBtu) and having at least 20% Reduction of Mercury from Coal to Stack
Scenarios 1-3 are based on a combined EMF approach to emission measurement
Scenarios 4-6 are determined from coal mercury content to final emissions
Missing Scenarios result from fewer than 3 plants

Table G–7. Algorithm Calculations Using Annual Average Chlorine and Sulfur Coal Content from ICR-II

Coal Rank	Scenario No	Plant ID	Unit Number	Technology Control Type	Annual Average Coal at Plant, lb Cl/TBtu	Annual Average Coal at Plant, ln(lb Cl/TBtu)	Annual Average Coal at Plant, Cl/S MBtu/TBtu	Annual Average Coal at Plant, lnCl/S MBtu/TBtu)	%Reduction, PModel1	%Reduction, PModel2	%Reduction, PModel3	%Reduction, PModel4
BITUMINOUS	1	SEI - Birchwood Power Facility	1	SDA/FF	74,646	11.22	1,189	7.08	0.9526	0.9060	0.1231	-4.6581
	2	SEI - Birchwood Power Facility	1	SDA/FF	74,646	11.22	1,189	7.08	0.9526	0.9060	0.1231	-4.6581
	3	SEI - Birchwood Power Facility	1	SDA/FF	74,646	11.22	1,189	7.08	0.9526	0.9060	0.1231	-4.6581
	4	Logan Generating Plant	Gen 1	SDA/FF	115,974	11.66	1,307	7.18	0.9724	0.9743	0.1252	-4.1437
	5	Mecklenburg Cogeneration Facility	GEN 1	SDA/FF	112,332	11.63	1,335	7.20	0.9713	0.9712	0.1257	-4.0342
	6	Logan Generating Plant	Gen 1	SDA/FF	115,974	11.66	1,307	7.18	0.9724	0.9743	0.1252	-4.1437
Lignite	2	Coyote	1	SDA/FF	9,347	9.14	65	4.17	0.3938	0.2687	0.1027	-106.174
	5	Antelope Valley Station	B1	SDA/FF	10,237	9.23	102	4.62	0.4578	0.2888	0.1033	-67.0310
Lignite North	2	Antelope Valley Station	B1	SDA/FF	10,237	9.23	102	4.62	0.4578	0.2888	0.1033	-67.0310
SUBBITUMINOUS	1	Craig	C1	HS-ESP/Wet FGD Scrubber	3,697	8.22	95	4.55	-0.2730	0.0681	-0.0213	-2.8288
	4	Presque Isle	9	HS-ESP	8,786	9.08	158	5.06	-0.0382	-0.0433	-0.0627	-0.7851
	5	Comanche	2	FF Baghouse	54,856	10.91	1,447	7.28	0.9076	0.8830	0.7746	0.5662
	6	Presque Isle	9	HS-ESP	8,786	9.08	158	5.06	-0.0382	-0.0433	-0.0627	-0.7851

Scenario 1+4: Best Performing Units as Ranked by Lowest Total Hg Emission (lb/TBtu)
Scenario 2: Best Performing Units as Ranked by Highest Percent Reduction of Mercury Across Control Device(s)
Scenario 3: Best Performing Units as Ranked by Lowest Total Hg Emission (lb/TBtu) and having at least 20% Reduction of Mercury Across Control Device(s)
Scenario 5: Best Performing Units as Ranked by Highest Percent Reduction of Mercury from Coal to Stack
Scenario 6: Best Performing Units as Ranked by Lowest Total Hg Emission (lb/TBtu) and having at least 20% Reduction of Mercury from Coal to Stack
Scenarios 1-3 are based on a combined EMF approach to emission measurement
Scenarios 4-6 are determined from coal mercury content to final emissions
Missing Scenarios result from fewer than 3 plants

Table G–8. Summary of Variability from Coal Switching (Chlorine or Sulfur Properties) at No 3. Facilities based on Algorithms

Coal Rank	Scenario No	Plant ID	Unit Number	Technology Control Type	%Hg Reduction, Calculated from Sampled Coal	%Hg Reduction, Calculated from Annual Average Coal at Plant	%Increase in Hg Emission, Sampled Coal to Annual Plant Average	%Hg Reduction, Calculated from the 95th perc. Annual Aver. Coal at All Plants	%Increase in Hg Emission, Sampled Coal to All Plants
BITUMINOUS	1	SEI - Birchwood Power Facility	1	SCR/SDA/FF	0.9513	0.9526	(3%)	0.7202	475%
	2	SEI - Birchwood Power Facility	1	SDA/FF	0.9513	0.9526	(3%)	0.7202	475%
	3	SEI - Birchwood Power Facility	1	SDA/FF	0.9513	0.9526	(3%)	0.7202	475%
	4	Logan Generating Plant	Gen 1	SCR/SDA/FF	0.9702	0.9724	(7%)	0.7202	838%
	5	Mecklenburg Cogeneration Facility	GEN 1	SDA/FF	0.9772	0.9713	26%	0.7202	1129%
	6	Logan Generating Plant	Gen 1	SDA/FF	0.9702	0.9724	(7%)	0.7202	838%
Lignite	1	Lewis & Clark	B1	PS/Wet FGD Scrubber					
	2	Coyote	1	SDA/FF	0.3810	0.3938	(2%)	0.4521	(11%)
	4	Lewis & Clark	B1	PS/Wet FGD Scrubber					
	5	Antelope Valley Station	B1	SDA/FF	0.4692	0.4578	2%	0.4521	3%
	6	Limestone	LIM1	CS-ESP/Wet FGD Scrubber					
Lignite North	1	Lewis & Clark	B1	PS/Wet FGD Scrubber					
	2	Antelope Valley Station	B1	SDA/FF	0.4692	0.4578	2%	0.4351	6%
	4	Lewis & Clark	B1	PS/Wet FGD Scrubber					
	5	Lewis & Clark	B1	PS/Wet FGD Scrubber					
SUBBITUMINOUS	1	Craig	C1	HS-ESP/Wet FGD Scrubber	0.2490	-0.2730	70%	-0.4543	94%
	2	Wyodak	BW 91	CS-ESP/SDA					
	3	Wyodak	BW 91	CS-ESP/SDA					
	4	Presque Isle	9	HS-ESP	-0.0159	-0.0433	3%	-0.0691	5%
	5	Comanche	2	FF Baghouse	0.7962	0.8830	(43%)	0.7921	2%
	6	Presque Isle	9	HS-ESP	-0.0159	-0.0433	3%	-0.0691	5%

Scenario 1+4: Best Performing Units as Ranked by Lowest Total Hg Emission (lb/TBtu)
Scenario 2: Best Performing Units as Ranked by Highest Percent Reduction of Mercury Across Control Device(s)
Scenario 3: Best Performing Units as Ranked by Lowest Total Hg Emission (lb/TBtu) and having at least 20% Reduction of Mercury Across Control Device(s)
Scenario 5: Best Performing Units as Ranked by Highest Percent Reduction of Mercury from Coal to Stack
Scenario 6: Best Performing Units as Ranked by Lowest Total Hg Emission (lb/TBtu) and having at least 20% Reduction of Mercury from Coal to Stack

Scenarios 1-3 are based on a combined EMF approach to emission measurement
Scenarios 4-6 are determined from coal mercury content to final emissions
Missing Scenarios result from fewer than 3 plants

Figure G–1. ICR-III Data for Algorithm Development for CS-ESP

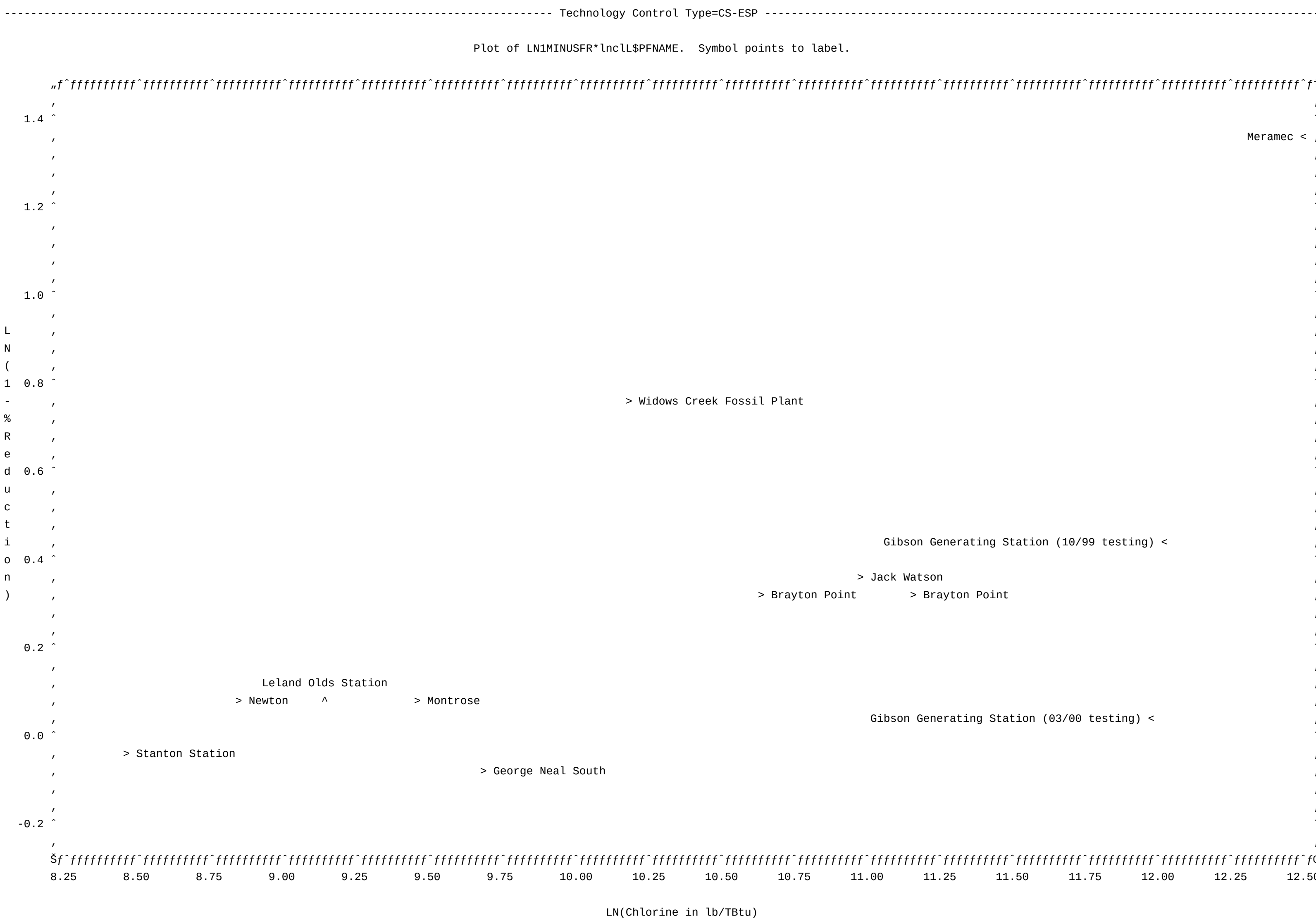


Figure G–2. ICR-III Data for Algorithm Development for CS-ESP/ Wet FGD

-- Technology Control Type=CS-ESP/Wet FGD --

Plot of LN1MINUSFR*lnclL$PFNAME. Symbol points to label.

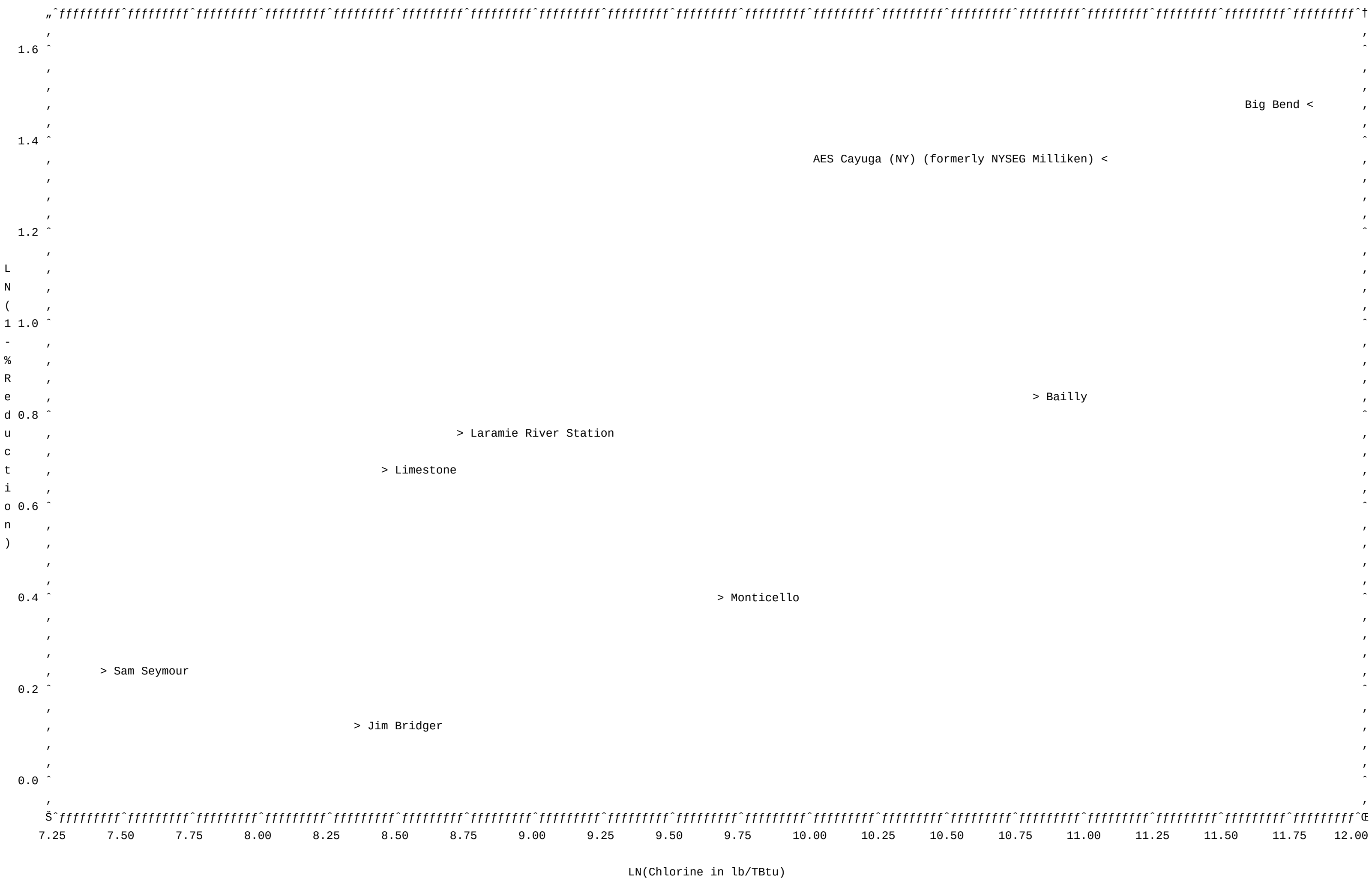


Figure G–3. ICR-III Data for Algorithm Development for FF Baghouse

Technology Control Type=FF Baghouse

Plot of LN1MINUSFR*lnclL$PFNAME. Symbol points to label.

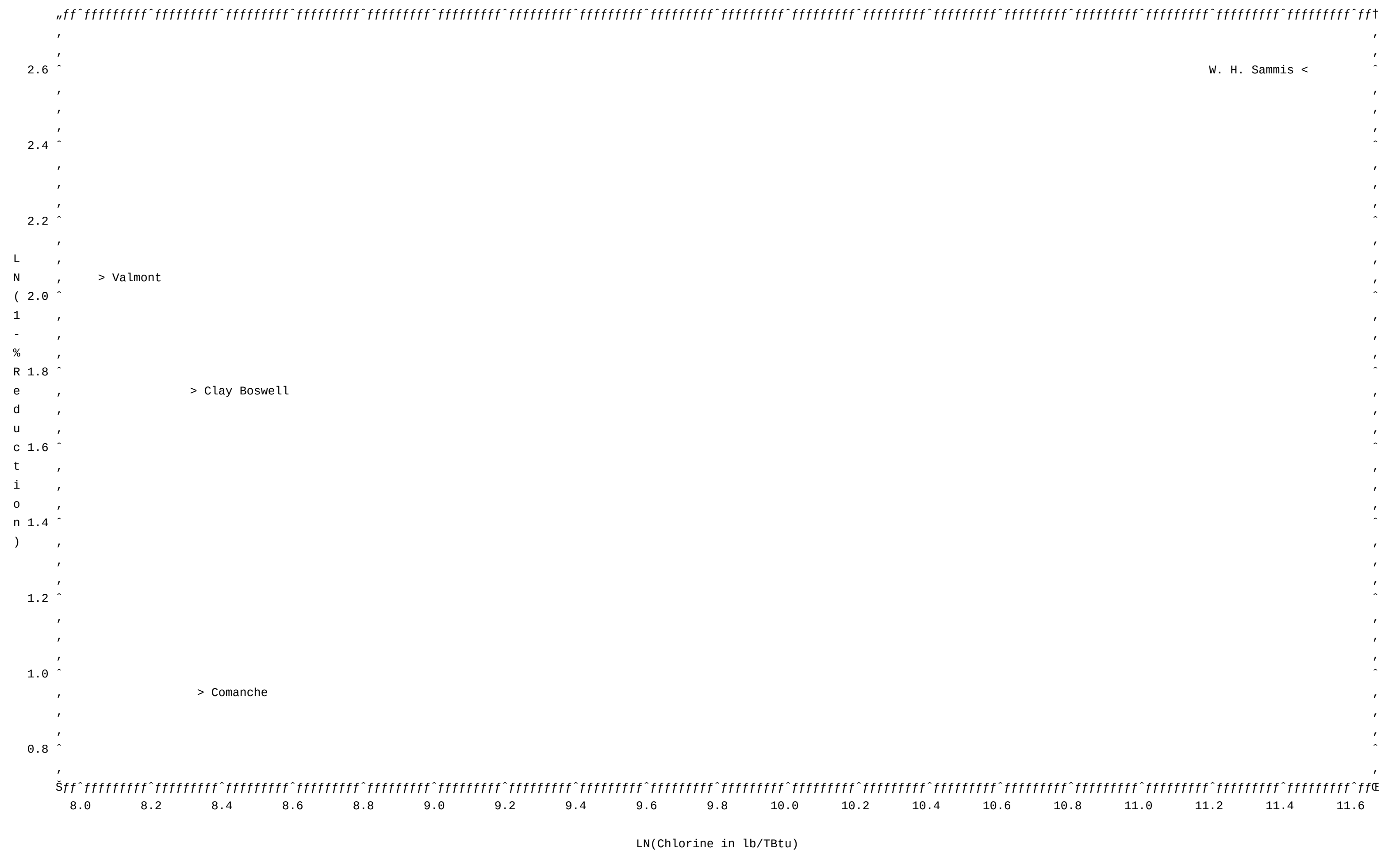


Figure G–4. ICR-III Data for Algorithm Development for HS-ESP

-- Technology Control Type=HS-ESP --

Plot of LN1MINUSFR*lnclL$PFNAME. Symbol points to label.

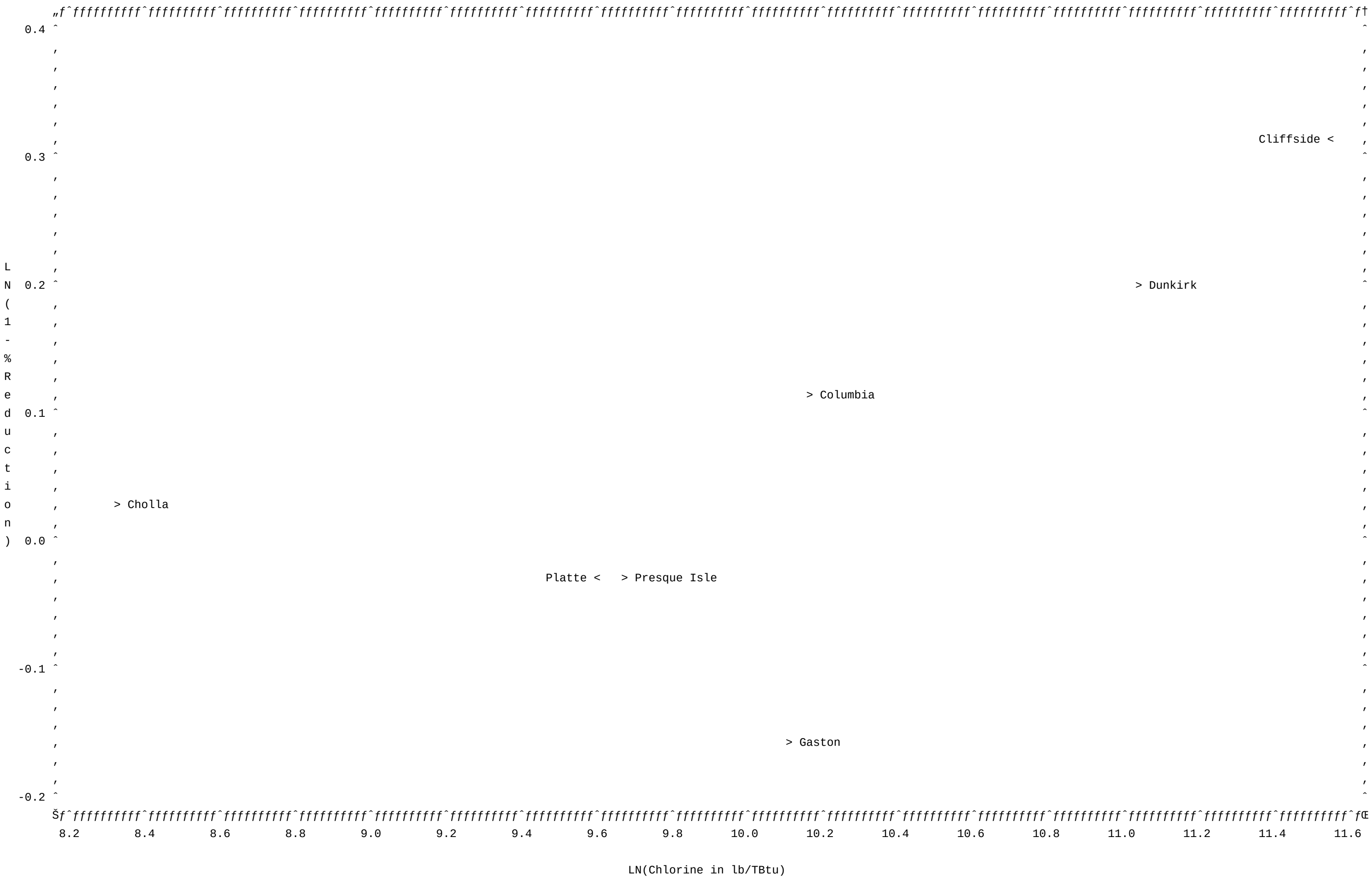


Figure G–5. ICR-III Data for Algorithm Development for HS ESP/ Wet FGD Scrubber

-- Technology Control Type=HS-ESP/Wet FGD Scrubber --

Plot of LN1MINUSFR*lnclL$PFNAME. Symbol points to label.

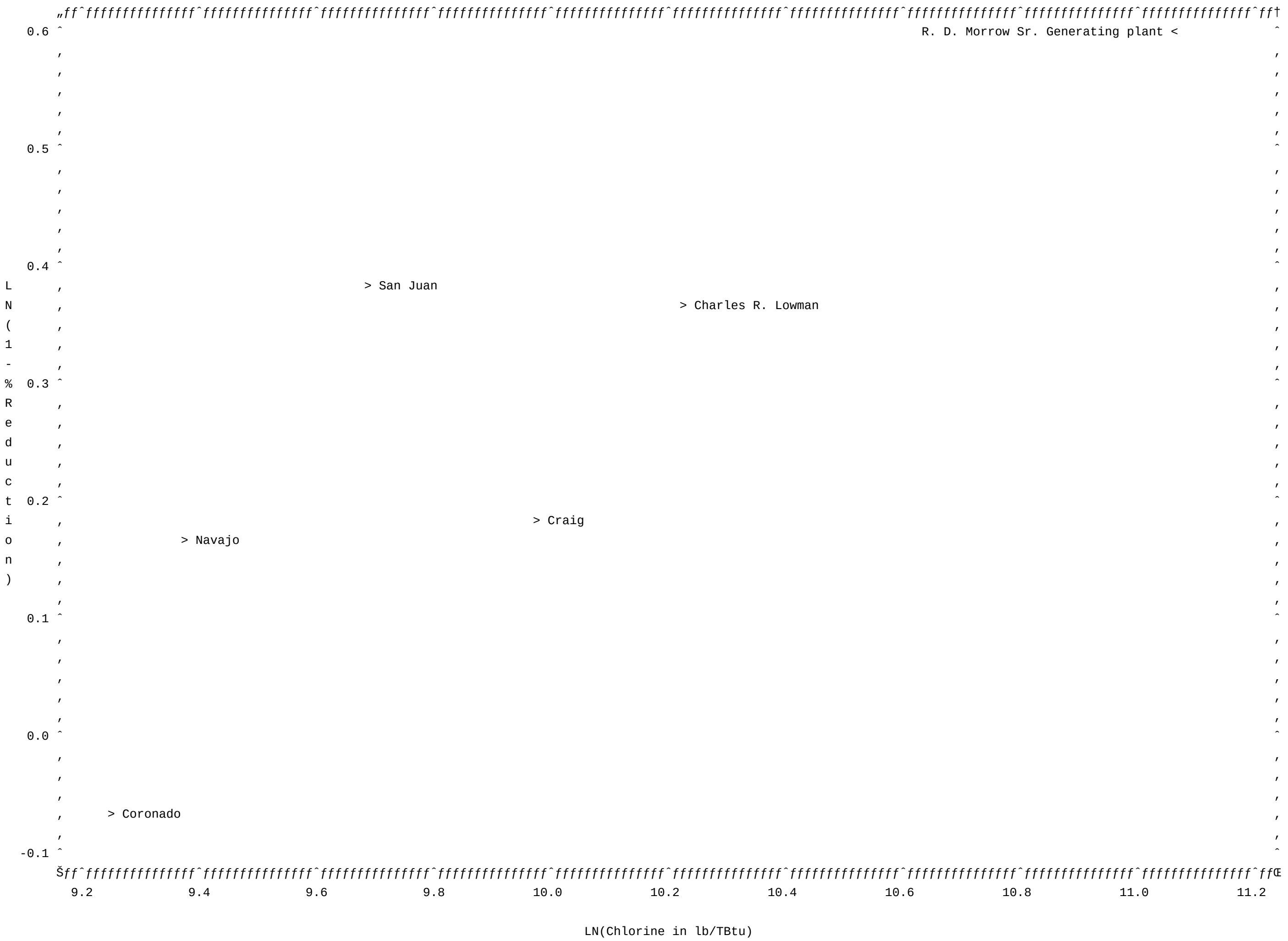


Figure G–6. ICR-III Data for Algorithm Development for PS/ Wet FGD

--- Technology Control Type=PS/Wet FGD ---

Plot of LN1MINUSFR*lnclL$PFNAME. Symbol points to label.

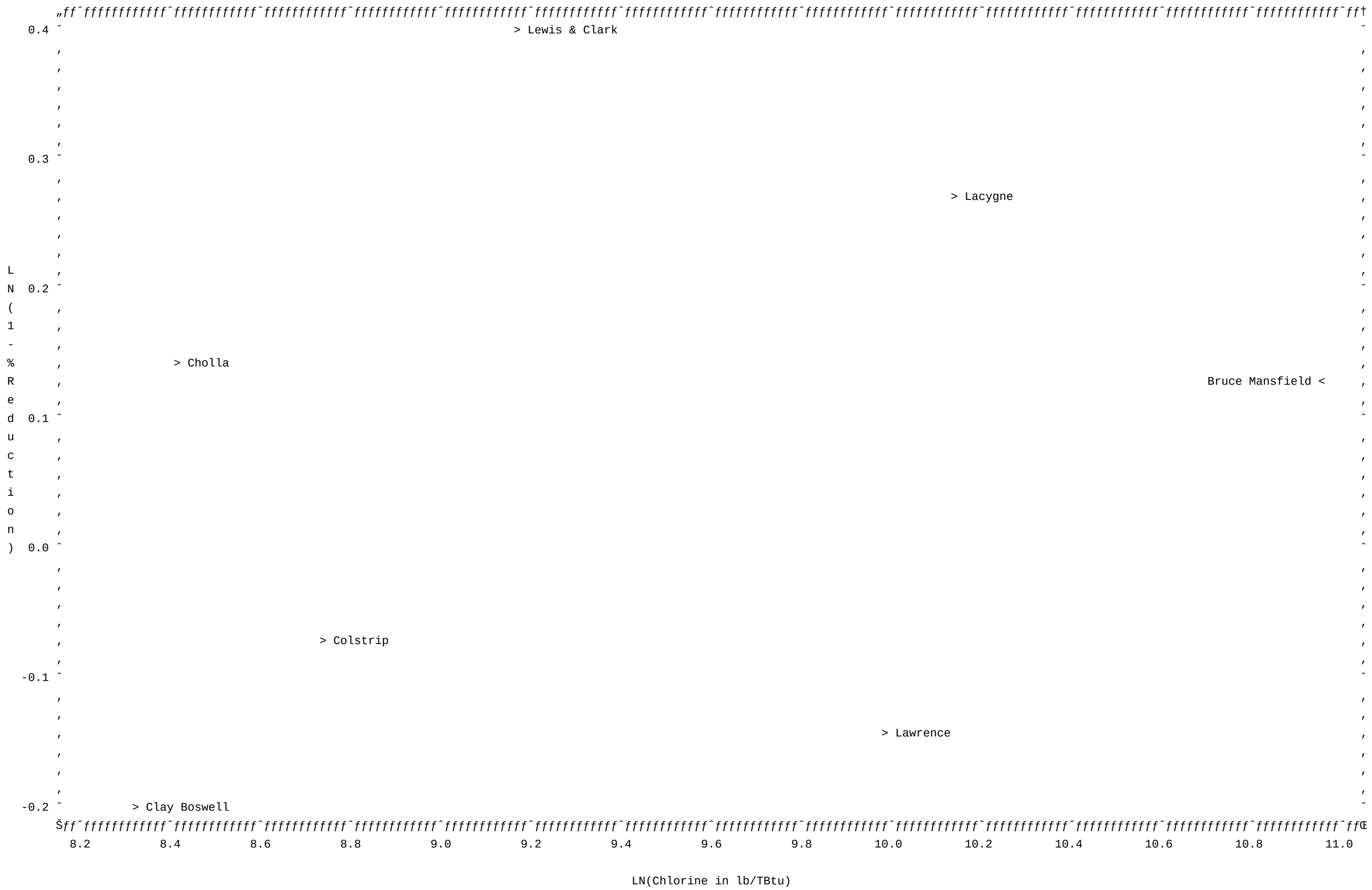
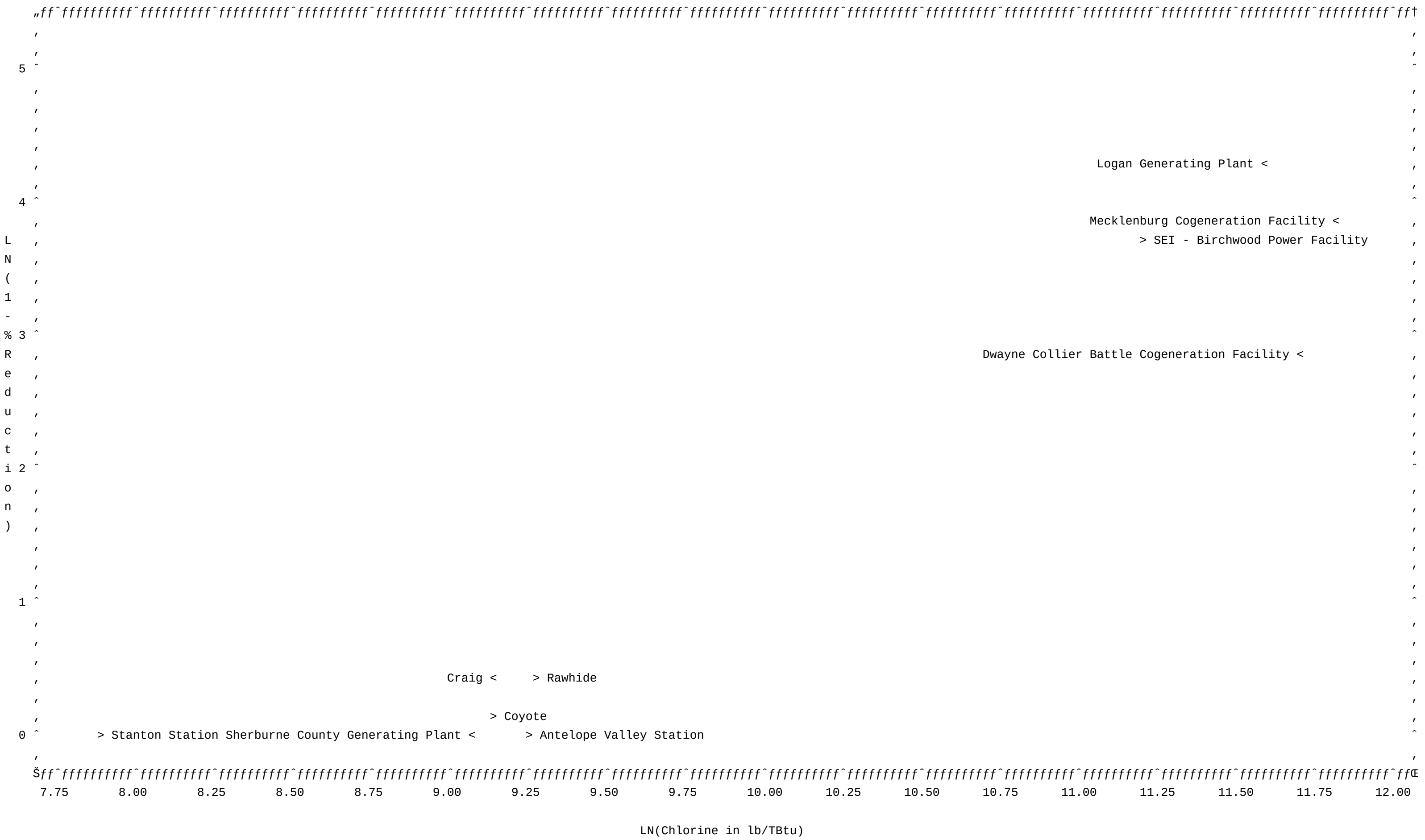


Figure G–7. ICR-III Data for Algorithm Development for SDA/ FF

Technology Control Type=SDA/FF

Plot of LN1MINUSFR*lnclL$PFNAME. Symbol points to label.



Appendix H. Extrapolation of Possible MACT Floor Values to Nationwide Mercury Emissions

The possible MACT floor values presented in this report (in units of lb/TBtu) are extrapolated to nation-wide emission estimates (in units of tons/year). The source data used for this analysis is the U.S. Department of Energy NETL Coal Power Plant Database 2000. This spreadsheet/ database was developed to assess the performance and cost of meeting simultaneous mercury, NOx, and SO2 emission targets. This was a useful starting point for the analysis due to the accessibility of source data.

This spreadsheet identifies: (1) the universe of utility coal combustion units; (2) the predominant coal used in 2000 (i.e., bituminous, subbituminous, or lignite, as determined from EIA Form 423) for each unit; (3) the coal heat input during 2000 (from EPA) for each unit; and (4) estimated mercury emissions for each unit, based on the plant's control devices present. This database is not identical to that used by EPA in developing its nationwide estimate (presented in EPA 2002), however it is useful in estimating differences between a baseline (pre-regulatory) value and subsequent impacts on emissions as a result of the possible MACT floor values.[1]

The starting (pre-regulatory) emission rate is estimated as 50 tons per year, using the Coal Power Plant 2000 Database with no adjustments. The use of this database gives only approximations in nationwide estimates. For example, all units are assumed to burn only one type of coal rank, corresponding to the predominant type of coal. In addition, the possible MACT floor values developed in this report are applied to FBC and IGCC units, which were specifically excluded from the onset in developing the MACT floor values. For each scenario, a range of nationwide mercury emissions and reduction were estimated; the endpoints of this range were calculated in the following manner:

- An upper end of the range was estimated by assuming that each unit releases mercury at the MACT floor. For example, if the unit burns 10 TBtu/year of bituminous coal, and the MACT floor for a given scenario is 5 lb/ TBtu, the unit is assumed to emit 50 lb mercury/ year.

- A lower end of the range was estimated by assuming that each unit releases mercury either at the MACT floor the MACT floor, or the quantity assumed to be emitted in 2000, whichever is lower. For example, if the unit burns 10 TBtu/year of bituminous coal, and the MACT floor for a given scenario is 5 lb/TBtu but the unit released only 2 lb/TBtu, the unit is assumed to emit 20 lb mercury/ year.

The results of these emission reductions for each scenario evaluated are presented in Chapter 5.

[1] One principal difference is that EPA 2002 assumes that the mercury level in the coal burned by the unit is equal to the average value found during the plant's ICR-II testing, while the NETL database makes a simplifying assumption that the unit's mercury level is equal to the average of all coals of the rank used originating from the same state. The resultant baseline emission estimates are similar for each data source (50 tons using NETL and 48 tons using EPA).